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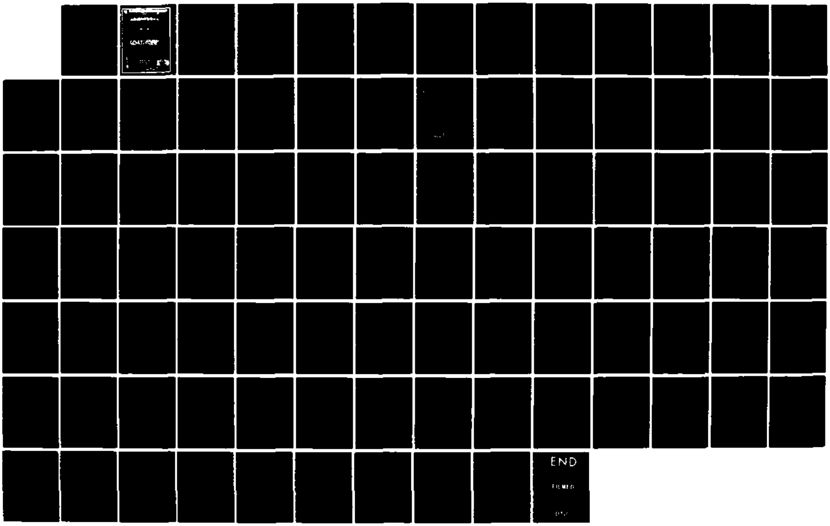

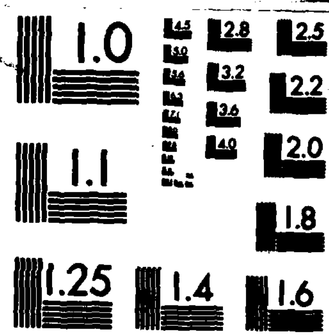

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Manangement Consulting & Research, Inc. (MCR) had the task of developing a linkage between training received at installation-level schools and maintenance productivity, as well as to examine other specific aspects of skill training for the Air Force F-16 aircraft. MCR examined Air Force training processes and maintenance reporting systems. Usable methodologies were developed and substantive conclusions reached. The affect on maintenace and training of simulated aircraft maintenance trainers was examined.

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MANAGEMENT CONSULTING & RESEARCH, INC.

TR-8302-1

SKILL TRAINING ANALYSIS--PHASE II: THE LINKAGE OF UNIT LEVEL SKILL TRAINING AND MAINTENANCE PRODUCTIVITY IN AIR FORCE F-16 UNITS

By

Rodney D. McConnell
Stuart C. Johnson

13 April 1984

Prepared For:

Office of the Assistant Secretary of Defense
Manpower, Installations and Logistics

Contract Number: MDA903-82-C-0278

Prepared By:

MANAGEMENT CONSULTING & RESEARCH, INC.
Four Skyline Place
5113 Leesburg Pike, Suite 509
Falls Church, Virginia 22041
(703) 820-4600

PREFACE

Management Consulting & Research, Inc. (MCR) provided support to the Office of the Assistant Secretary of Defense (OASD) for Manpower, Installations and Logistics (MI&L) under contract number MDA903-82-C-0278 for the examination of skill training. MCR analyses will assist in the evaluation and support of Service training programs.

This technical report is a contract deliverable that documents the skill training analyses conducted during this project to determine the linkage between installation level training and maintenance productivity, using data from the F-16 aircraft. We were able to determine trends and establish relationships between Air Force Field Training Detachment (FTD) training and maintenance productivity. We also determined that the use of simulators for training, instead of real aircraft, did not degrade the maintenance productivity of units. Thus, it can be shown that simulators provided a cost savings in training.

We would like to acknowledge the continuing guidance and assistance of the members of the Training and Education Directorate, particularly Mr. Gary Boycan, Mr. Michael J. Kendall, and Lt. Col. R. P. Tyndell. Also, the assistance and cooperation of the Air Staff and members of the Tactical Air Command (TAC) made our work possible.

EXECUTIVE SUMMARY

This summary includes the study purpose, organization of this report, results and observations.

A. STUDY PURPOSE AND REPORT ORGANIZATION

The purpose of this study was to analyze individual skill training conducted at the installation level and determine the linkage between this installation level training and maintenance productivity. The authors ~~We~~ used units containing the Air Force F-16 aircraft for our sample since it is one of our newest airplanes and it required extensive training/retraining of maintenance personnel. The use of simulated aircraft maintenance trainers, rather than actual aircraft for training, was specifically included in our analysis both in terms of training capability and cost savings. The ~~Our~~ task included these subtasks:

- 1) identify measures of maintenance productivity;
- 2) identify training status of organizations and individuals;
- 3) reexamine and develop analytical methods for linking training and productivity;
- 4) analyze information and evaluate results; and
- 5) document the results of the analysis.

This report contains three sections. Section I, Introduction, describes the purpose, background, approach, and organization of this report. Section II, Skill Training Evaluation, describes Air Force maintenance, Air Force training, research background, and methodology. Section III, Application

of Methodology and Results, describes the application of our methodology, results, and observations.

B. RESULTS AND OBSERVATIONS

As a result of our analysis of Air Force maintenance and training in five wings we determined that training had a statistically significant effect on maintenance productivity. We examined F-16 aircraft maintenance and training for three major maintenance areas and the related skills: flight controls, jet engine, and electrical systems. We looked for trends using graphical techniques and then applied the analysis of variance (ANOVA) statistical test.

In order to look at the effects of the use of aircraft simulators we compared two wings that had been trained differently: one with simulators and one without. Also, we found that the use of simulators required fewer aircraft in support of maintenance training.

Our overall intention of showing a relationship of training to maintenance productivity was successful and provides quantified data to support the conclusion that installation level training increases productivity. The graphic representations of frequency (number of work actions taken) and level of training versus productivity lead us to the conclusion that there is a positive relationship between amount of training and productivity at the installation level. The statistical results using ANOVA indicate that for jet engine maintenance and its related skill, as well as for electrical systems maintenance and its related

skill, our findings are statistically significant at the 90 percent confidence level. We also found a positive relationship for flight control maintenance, and its related skill, but at a lower confidence level.

The wing that was trained using simulators at Luke AFB performed maintenance as productively as the wing at Nellis AFB that was trained without simulators. This was accomplished with a cost avoidance of approximately one-half aircraft assigned to support training throughout the period observed. This cost avoidance shows that use of simulators for training can save money and also contribute to readiness by allowing additional aircraft to be assigned to operational purposes.

It is apparent from this research that the interim results reported previously have been reinforced by our current analysis. It is obvious that training does directly influence maintenance and that delaying the training of new maintenance personnel is detrimental to productivity. The wing analysis and training sections are not presently attempting this linkage of training and maintenance since their primary concerns are to improve operational flying capability. Thus, data is collected on maintenance, and training is conducted, but the two are not being correlated. If wing headquarters personnel were able to do analyses similar to ours, they should be able to show where training needs reinforcement so as to positively affect maintenance.

Some improvements to maintenance data collection could benefit the current system and assist analysis at the wing level.

The first would be the entry of employee number for all maintenance crew personnel in the maintenance data collection system. This would allow direct and precise measurements of training and productivity for individuals and work centers. A second improvement would be a greater use of component level designation for maintenance reporting rather than system or subsystem designation. This would allow more refined analyses to be performed and would more precisely define what work is being done. Finally, the current set of action taken codes does not sufficiently define what maintenance tasks are being performed. This is only pertinent when applied to higher level, system or subsystem, designation. If component level designation were always used then the current action taken codes would prove to be adequate.

TABLE OF CONTENTS

LIST OF EXHIBITS

LIST OF EXHIBITS (CONT'D)

I. INTRODUCTION

This section discusses the following:

- Purpose,
- Background,
- Approach, and
- Organization of this Report.

A. PURPOSE

The purpose of our study was to analyze the linkage between installation level training and maintenance productivity. Specifically, we concentrated on Air Force F-16 wings. The F-16 aircraft is the newest addition to the Air Force tactical inventory and the first to use simulated aircraft maintenance trainers (SAMTs), or simulators, for training mechanics. This is important to our analysis since it allowed comparison of newly converted wings to wings converted at an earlier period. The intent was to collect information from five wings located in the continental United States (CONUS) for ease of data collection and to compare this data in our linkage determination. The task consisted of five subtasks:

- identify measures of maintenance productivity,
- identify training status of organizations and individuals,
- reexamine and develop analytical methods for linking training and productivity,
- analyze information and evaluate results, and
- document the results of the analyses.

B. BACKGROUND

OASD (MI&L) has issued policy guidance that manpower impacts will be considered in system design and operation. This consideration requires both the Office of the Secretary of Defense (OSD) and the Services to develop improved methods for evaluating manpower, personnel, and training. The analysis of critical skills, particularly the impact of required level of maintenance skills on quality of maintenance, is a key factor in these evaluations. Individuals who are required to operate and maintain weapons systems reach the journeyman level through individual training conducted at the installation level.

Due to a growing concern for the problems in maintaining and operating existing weapons systems, a comprehensive review of training was initiated by OASD (MI&L). Some initial work has been completed concerning how weapons systems support can be improved with better training. In their first report[1/] MI&L describes existing on-the-job training (OJT) programs and proposes ways to enhance training, especially OJT, in order to improve equipment maintenance. In a later report[2/], MI&L provides an overview of the systems developed to train individuals in selected maintenance skills. The report covers the entire training plan, from initial skill training in formal schools to individual skill training received in the unit. Based on these completed and on-going study efforts, and in support of

1/ Report on the OJT Study Task: On-The Job Training in the Department of Defense, OASD (MRA&L) under the auspices of the Defense Education and Training Executive Committee, January 1981.

2/ Report on Individual Skill Training: Maintenance Training in the Department of Defense, OASD (MRA&L), May 1982.

the MI&L Training and Education Directorate, MCR completed Phase I of an analysis to develop a linkage between individual training conducted at the installation level and unit productivity.[3/]

During Phase I, MCR examined Army, Navy and Air Force training/operational activities. Of particular relevance are Tasks 1 and 4 which analyzed Air Force units and established methods of linking training and maintenance. Task 1 concentrated on the impact of installation training on unit maintenance productivity, using F-4 and F-15 input data, and was very beneficial in showing the utility of the work unit code trend analyses. Task 4 examined the use of SAMTs and further defined the linkage of training and productivity by developing methods for examining several aspects of this linkage. The Phase I research provided a firm basis for the analysis conducted in this current work.

C. APPROACH

The linkage between training and productivity is tenuous under any circumstances, since so many other factors can influence work productivity. Such things as reporting procedures, facilities, and parts availability can change the results achieved. However, intuitively, training must have an effect on maintenance productivity and, if a large enough sample is chosen and carefully analyzed, effects should become apparent. The introduction of a maintenance simulator is an additional variable

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3/ Rodney D. McConnell et al., Skill Training Analysis: The Linkage of Unit Level Skill Training and Unit Productivity, TR-8202-1, Management Consulting & Research, Inc.; 14 June 1983.

that is not easily measured, since training will occur whether the simulator is available or not. The simulator does allow the student to diagnose rare problems and thus, on the occasion that something out of the ordinary occurs, be able to fix it properly. The simulator appears to provide a means of achieving a higher quality of maintenance, although our method of measuring productivity by time-to-repair will not make this readily obvious. However, our intent was to show that the simulator provides training equal to that obtained using a real aircraft. Thus, the aircraft are freed for operational use at a cost savings to the Air Force.

In our analysis of the linkage of unit level skill training and productivity, our focus was on maintenance. The approach we followed was to choose specific, highly visible skills and to examine the training provided and the related maintenance tasks performed. This required an initial research effort to find appropriate skills that required installation-level training or for which training was provided. Also, the initial research effort focused on available sources of maintenance measures of productivity. The intent of our analytical effort was to establish specific quantitative linkages between skill training provided by units and maintenance productivity.

The approach we used relates training received by maintenance personnel at the installation level to on-the-job performance. This approach includes:

- identifying skills taught using maintenance simulators at the wing level, and

- developing methods for analyzing the impact of these learned skills on maintenance productivity.

The research focused on maintenance skills critical to the operation of the F-16 aircraft. The study was conducted in the following order:

- Select appropriate sample organizations;
- Make visits to selected operational units and their supporting FTDs to examine unit training and maintenance;
- Request and receive training status and maintenance productivity information from the units selected;
- Research the use of simulated aircraft maintenance trainers (SAMTs) by FTDs for training maintenance personnel at the wing level;
- Reexamine and develop methods for analyzing the data;
- Analyze the data; and
- Document the results.

D. ORGANIZATION OF THIS REPORT

Following this introduction are two other sections of the report:

- Skill Training Evaluation, and
- Application of Methodology and Results.

Section II, Skill Training Evaluation, discusses Air Force maintenance, Air Force training, research background, and methodology.

Section III, Application of Methodology and Results, discusses the application of our methodology, results, and observations.

Supporting information is presented in three appendices:

- Reference Sources,
- Backup Data, and
- Abbreviations.

II. SKILL TRAINING EVALUATION

In our previous research we set out to establish a linkage between individual training and maintenance productivity. The results of that research showed definite quantitative relationships could be established.[4] We used individual maintenance personnel training information maintained by the wing maintenance training section within the training subsystem of the Maintenance Management Information and Control System (MMICS). Maintenance productivity was measured using the number of work hours needed to complete a maintenance action. This information was extracted from the Maintenance Data Collection (MDC) system based on information routinely entered by work centers performing maintenance. These same sources were used in this phase of our work with improved results using increased sample size and additional analytical evaluations.

This section describes the following topics:

- Air Force Maintenance,
- Air Force Training,
- Research Approach, and
- Methodology.

A. AIR FORCE MAINTENANCE

In this section we will discuss Air Force maintenance from the perspective of information availability and where it is performed organizationally. The following subsections discuss:

4/ Ibid

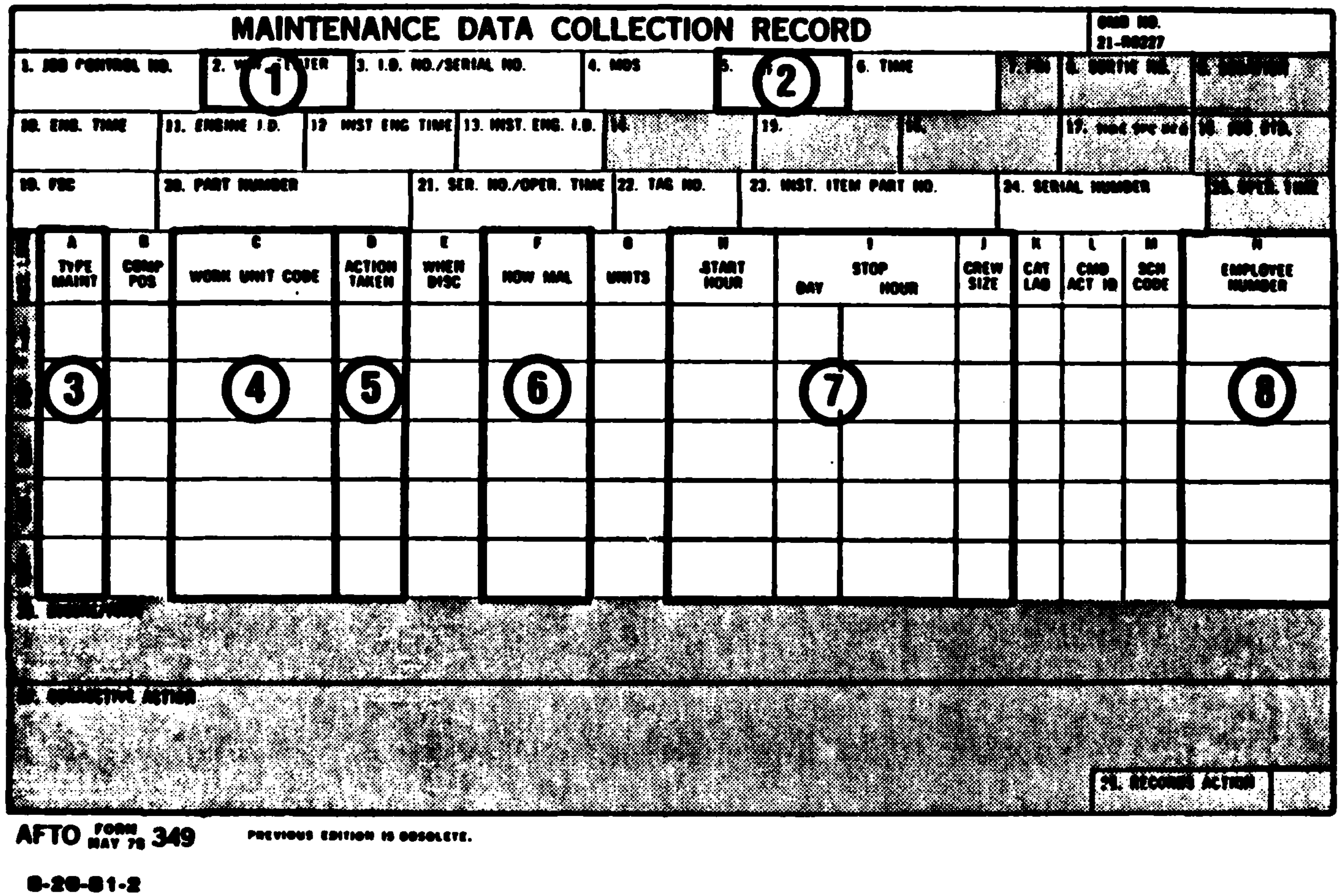
- Maintenance Data Collection, and
- Maintenance Organization.

1. Maintenance Data Collection

The Air Force maintenance system is described in AFR 66-1[5/] and documents a sufficient amount of information to ascertain what was worked on, what was wrong, what was done, and who did it. The mechanic or supervisor prepares a Maintenance Data Collection Record (AFTO Form 349) which is used to record data for the MDC system.

An example of this form is shown on Exhibit II-1. "The Maintenance Data Collection Record is used to record all maintenance in the 66-1/66-5 systems. Equipment being maintained is identified by the values of the work unit code (WUC) 4 and the SRD 2 . (SRD, or Standard Reporting Designator, is a three character code that denotes the type of equipment end-item.) What is wrong with the equipment is given by the how-malfunction code 6 . What was done in the course of maintenance is contained in the type-maintenance 3 and action-taken 5 codes. Who performed the maintenance task is identified through the combination of work center 1 and the maintenance organization containing the work center, where the identification of the organization is provided by the processing routines that transfer the hardcopy information to MDC records. Man-hours expended are calculated during ADP processing from the start-hour, stop-hour, and crew size values contained in 7 . A separate line of

5/ Equipment Maintenance: Maintenance Management, Air Force Regulation (AFR) 66-1, Headquarters, U.S. Air Force, 2 July 1980.


MAINTENANCE DATA COLLECTION RECORD

OMB NO. 21-R0227

1. JOB CONTROL NO. | 2. W... CENTER | 3. I.D. NO./SERIAL NO. | 4. MDS | 5. | 6. TIME | 7. ... | 8. SORTIE NO. | 9. ...

10. ENG. TIME | 11. ENGINE I.D. | 12. INST ENG TIME | 13. INST. ENG. I.D. | 14. | 15. | 16. | 17. ... | 18. ... STD.

19. FSC | 20. PART NUMBER | 21. SER. NO./OPER. TIME | 22. TAG NO. | 23. INST. ITEM PART NO. | 24. SERIAL NUMBER | 25. OPER. TIME

A TYPE MAINT | B COMP POS | C WORK UNIT CODE | D ACTION TAKEN | E WHEN DISC | F HOW MAL | G UNITS | H START HOUR | I STOP DAY HOUR | J CREW SIZE | K CAT LAB | L CMD ACT ID | M SCH CODE | N EMPLOYEE NUMBER

1 2 3 4 5 6 7 8

26. DISCREPANCY

27. CORRECTIVE ACTION

28. RECORDED ACTION

AFTO FORM MAY 78 349 PREVIOUS EDITION IS OBSOLETE.

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Exhibit II-1. MAINTENANCE DATA COLLECTION RECORD

information is recorded each time there is a change in any of the columns A through N, including changes in crew size or composition, and each line results in a distinct record. Employee number 8 typically names a shop supervisor or lead technician and should not be a reliable guide to identifying individuals actually performing maintenance; in addition, this information is not transferred to MDC records."[6]

The improved F-16 Consolidated Data System (CDS) uses the same AFTO Form 349 as input but allows for supervisor comments to be added. The advantage of CDS over MDC is the ability to aggregate maintenance information in a more useable form and with flexibility as to what data is displayed. The obvious information needed is what was worked on (work unit code or WUC), what was done (action taken code), how many workhours were used, and who did the work (work center).

2. Maintenance Organization

Organizationally, each wing contains both flying squadrons and maintenance squadrons. Exhibit II-2 shows the typical wing organization. It should be noted that within the Aircraft Generation Squadron there is an Aircraft Maintenance Unit (AMU) for each flying squadron. The AMU provides organizational maintenance support. The other maintenance squadrons provide intermediate maintenance support.

6/ J. Orlansky and J. String, Evaluating the Effectiveness of Maintenance Training by Using Currently Available Maintenance Data, IDA Paper P-1574, Institute for Defense Analyses, August 1981.

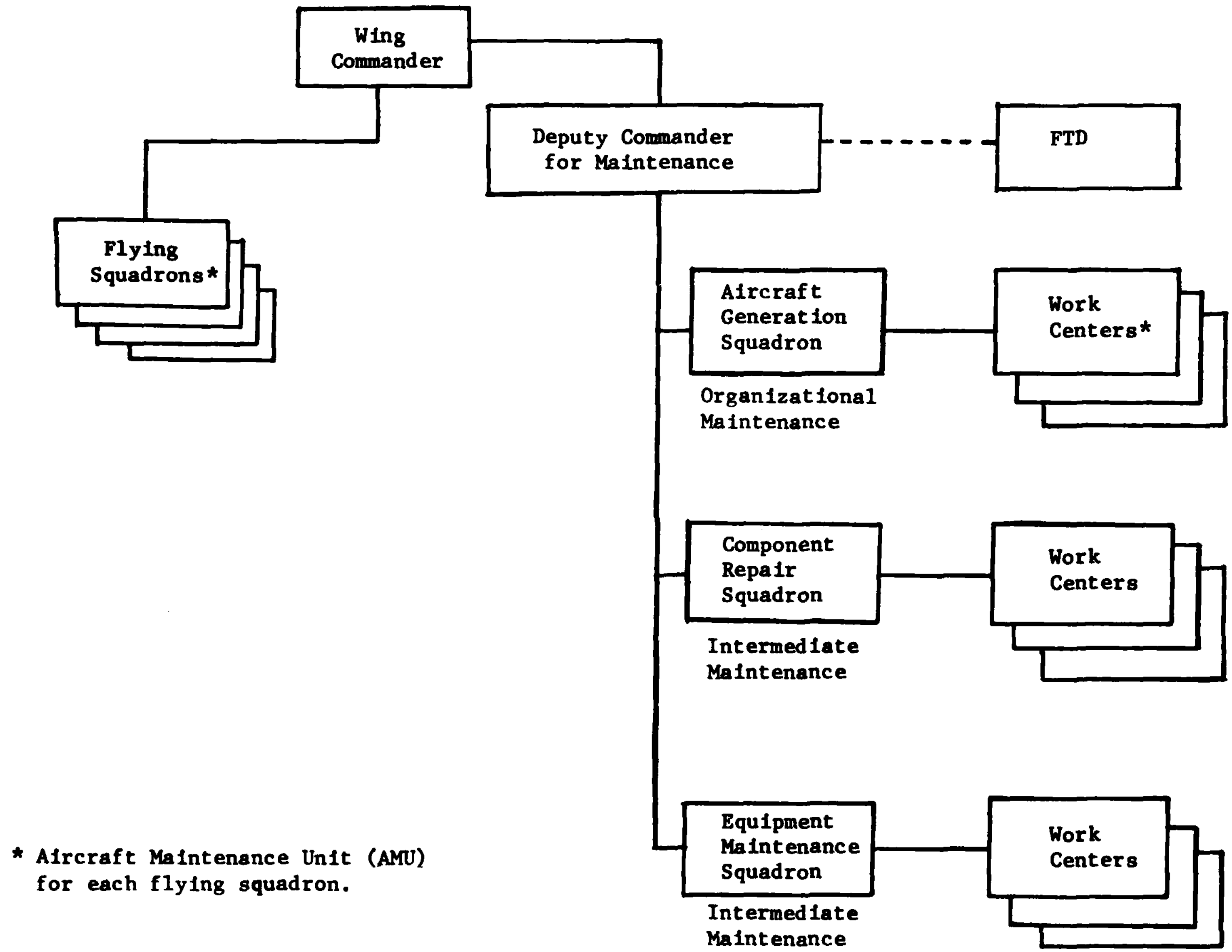

Exhibit II-2. TYPICAL TACTICAL WING ORGANIZATION

Our research focused on FTDs assigned to the Tactical Branch which supports TAC. Exhibit II-2, shows the relationship between the maintenance structure of a tactical wing and its supporting FTD. Typically, there are three or four flying squadrons in a wing. The Deputy Commander for Maintenance (DCM) manages equipment maintenance for these flying squadrons. The DCM is also responsible for assuring that maintenance training (FTD, OJT, and informal programs) is effective. Maintenance work is performed by work centers in the Aircraft Generation Squadron (AGS), Component Repair Squadron (CRS), and Equipment Maintenance Squadron (EMS). Some work centers are manned primarily by personnel trained in a single skill area (e.g., all jet engine mechanics), while others are manned by personnel trained in several skill areas (e.g., integrated avionics specialists, aircraft electrical systems specialists, and jet engine mechanics). Team maintenance (two or more individuals performing a single maintenance task) is standard procedure in most wings. Cross-skill maintenance (personnel who are trained in one skill area performing a maintenance task associated with a different skill area) is performed as required by workload and personnel shortages.

B. AIR FORCE TRAINING

The focus of this study is the impact of training conducted at the installation level on maintenance job performance. The typical training flow for Air Force maintenance personnel is shown on Exhibit II-3. These enlistees attend initial entry

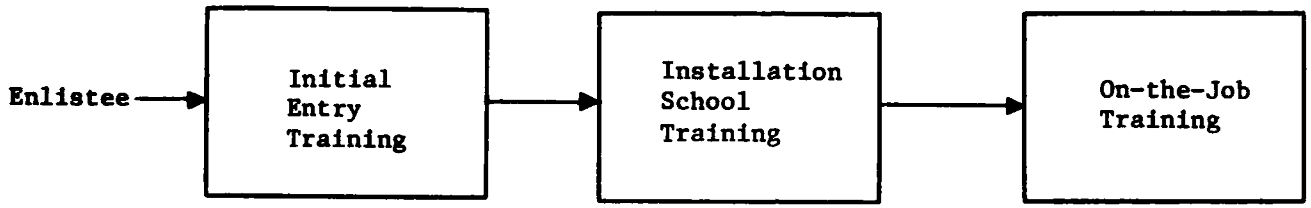

Exhibit II-3. TYPICAL TRAINING PATH OF AIR FORCE MAINTENANCE PERSONNEL

training (basic military training and technical school) prior to assignment. During technical school, they will learn the basic skills required within their Air Force Specialty Code (AFSC). Next, they receive equipment-specific training in an installation Field Training Detachment (FTD). Much of this FTD training uses simulators. This is followed by on-the-job training (OJT) in the unit.

The following subsections discuss:

- Installation Training, and
- Aircraft Maintenance Simulators.

1. Installation Training

The primary functions of an installation school include the following:

- to supplement the generalized training received in formal schools with equipment-specific training related to types of equipment located at that installation;
- to provide transition training to personnel whose previous experience has been on other models of equipment; and
- to provide upgraded and refresher training.

There are two types of installation schools: officially recognized schools and unofficial schools. Officially recognized schools are specifically funded and are manned in accordance with authorization documents. Although these schools belong to the training command, their main purpose is to meet the specific needs of the associated unit at the installation. Included among the officially recognized schools are the Air Force Field

Training Detachments, which focus on aviation maintenance training.

Unofficial installation schools are established by an operational unit, using its own manpower and funding resources. In the Air Force, unofficial schools are used extensively in the Tactical Air Command (TAC). The unofficial schools in TAC provide training in addition to that provided by the FTDs.

Most of the installation school training in the Air Force takes place at FTDs. Exhibit II-4 shows the organizational relationship between the Air Training Command and the FTDs.

2. Aircraft Maintenance Simulators

The use of aircraft maintenance simulators can be very helpful in conducting skill training. This section addresses these topics: the effects of having maintenance simulators, a description of what kind of simulators are available for F-16 training at the wing level, and what the simulators are used for.

a. Effects of Having Maintenance Simulators

As a training device, a maintenance simulator can be designed to provide facilities important for instructing students, in contrast to actual equipment that is designed to operate effectively in an operational environment. Maintenance simulators can be designed to include a large variety of faults with which maintenance personnel should be familiar, including faults that cannot be demonstrated conveniently on actual equipment trainers or faults that occur rarely in real life.

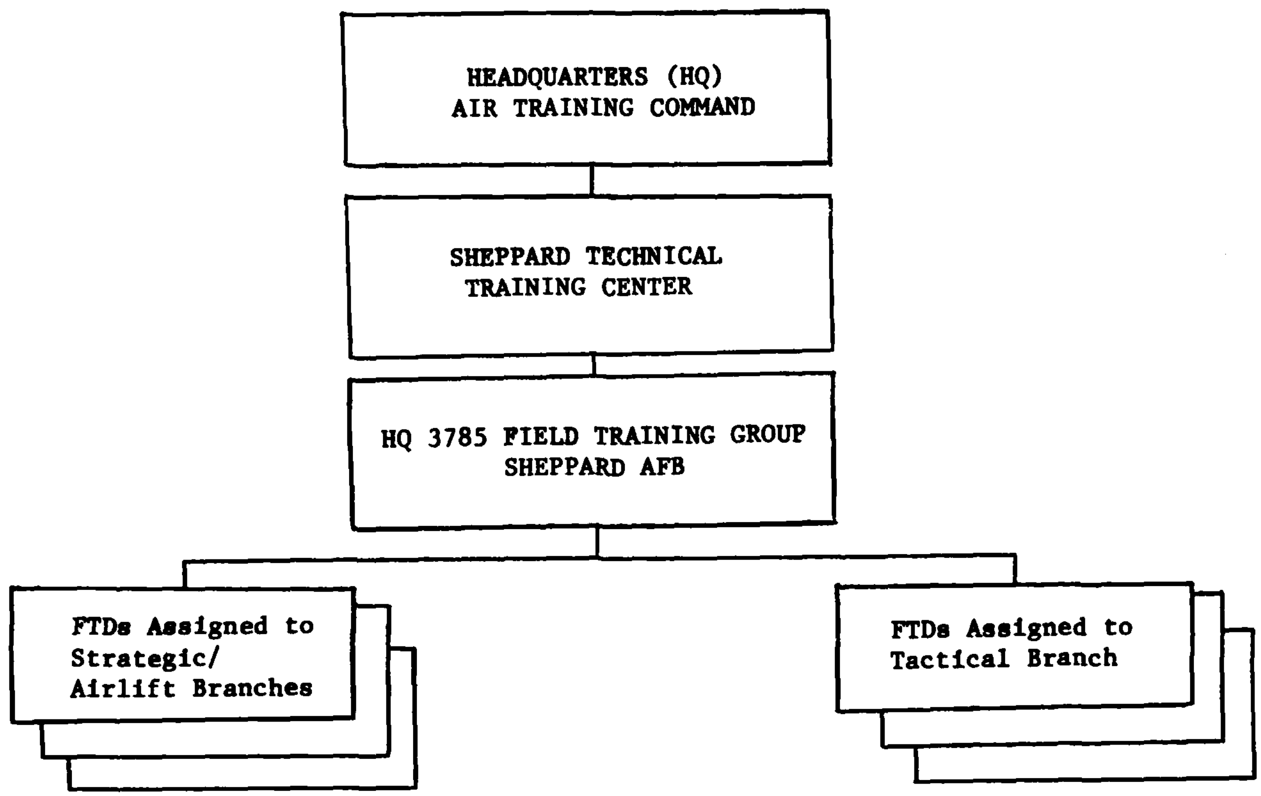

Exhibit II-4. AIR TRAINING COMMAND - FIELD TRAINING DETACHMENT RELATIONSHIP

All modern maintenance simulators incorporate some type of computer support. This support provides numerous training enhancements.

- The computer can automatically record student responses to training situations, thereby reducing the need for constant observation by the instructor (and providing accurate records of performance).
- The computer can assist students without an instructor's intervention.
- The instructors can use information collected by the computer to better guide each student through training by focusing on weak areas.

Simulators can be made rugged enough to sustain damage or abuse by students and thus provide greater reliability and availability in the classroom than is often possible with actual equipment. Training which would be avoided because of safety reasons (e.g., exposure of students to dangerous electrical charges or hydraulic pressures) can be undertaken with little risk on a simulator.

F-16 maintenance training conducted at the FTD level is enhanced by the use of aircraft simulators. These simulators are organized into sets. A full set may have 11 different simulators or trainers. Each individual trainer simulates different functions aboard the aircraft. These simulators are divided into two major types:

- Simulated Aircraft Maintenance Trainers (SAMTs). These computerized, fault-oriented trainers provide an advanced method of training maintenance technicians to diagnose and correct system malfunctions. SAMTs provide a method of teaching operational procedures in a very cost-effective manner. Power requirements are lower than with actual equipment, and simulator system response to student inputs is identical to that of the aircraft.

- Hardware Trainers. These trainers provide a physical simulation of actual maintenance areas. These simulators focus on "hands-on" training experiences for the repair of common malfunctions in some of the more mechanical areas of the aircraft; diagnostic skills are not stressed within these simulators.

b. F-16 Aircraft Maintenance Simulators

The full group of simulators is called a mobile training set (MTS) and consists of seven SAMTs and four hardware simulators (or trainers). Each simulator is numbered, although not all numbers are used. Six SAMTs are manufactured by Honeywell and one by Educational Computer Corporation (ECC). The hardware trainers are made by General Dynamics. The list below shows simulator number, title and manufacturer:

Simulator Number	Simulator Title and Manufacturer
2	SAMT--Flight Control/Instrumentation (Honeywell)
3	SAMT--Navigation (Honeywell)
4	SAMT--Electronics (Honeywell)
6	Hardware--Seat and Canopy (General Dynamics)
7*	SAMT--Hydraulics (Honeywell)
10	SAMT--Engine Start (Honeywell)
11	SAMT--Engine Diagnostics (Honeywell)
12	SAMT--Engine Operating Procedure (Honeywell)
13	Hardware--F-100 Engine (General Dynamics)
14	Hardware--Gun (General Dynamics)
15	Hardware--Fuel (General Dynamics)
22	SAMT--Environmental Control (ECC)

*No longer in use.

c. Use of Simulators

The following listing shows the simulator number and title, aircraft equipment repairs by primary work unit codes (WUCs) taught using the simulators, and the course title/AFSC for which the simulator is used.

Simulator	WUC--Aircraft Equipment	Courses--AFSC
2, Flight Control/ Instrumentation	14A00, Primary Flight Control Electronics 14B00, Primary Flight Control Actuators 51A00, Primary Flight Instruments 51F00, Control Air Data Computer	Integrated Avionics Instrument and Flight Control System Specialist (F-16); for AFSC 326X7.
3, Navigation	71A00, TACAN Navigation Set 71B00, Instrument Landing Set	Integrated Avionics Navigation, and Pen-etration Aids Systems Specialists (F-16); for AFSC 326X8.
4, Electronics	42000, Electrical Power Supply	Aircraft Electrical Systems Technician (F-16); for AFSC 423X0.
6, Seat and Canopy	12000, Crew Station System	Aircrew Egress Systems Technician (F-16); for AFSC 423X2.
10, Engine Start 11, Engine Diagnos-tics 12, Engine Operat-ing Procedure 13, F-100 Engine	23000, Turbofan Power Plant; 24000, Auxiliary Power Plant	Jet Engine Technician (F-16); for AFSC 426X4.
14, Gun	75A00, Gun System	Weapons System Maintenance Technician (F-16); for AFSC 462X0.
15, Fuel	46000, Fuel System	Aircraft Fuel Systems Technician (F-16); for AFSC 423X3.
22, Environmental Control	41000, Environmental Control System	Aircraft Environmental System Technician (F-16); for AFSC 423X1.

C. RESEARCH BACKGROUND

This study examines and quantifies the impact of FTD training, particularly training that uses maintenance simulators, on maintenance productivity. We relate efforts, measured in workhours to complete a maintenance action, to work center training status.

Many factors, beyond training at the unit/base level and the use of actual or simulated equipment, can profoundly influence our capability to maintain military equipment. These factors include:

- quality of personnel recruited by the Military Services,
- policies used by the Services to assign recruits to occupational specialties,
- amount and type of training to be accomplished at technical schools,
- complexity of the information that must be assimilated in order to accomplish maintenance,
- quality of maintenance supervision,
- equipment design, and
- maintenance policy.

These factors are recognized as being important considerations in equipment maintenance analyses, but, due to our specific concern in this study on training and maintenance simulators, these factors are not explicitly addressed. The remainder of this section on research background discusses:

- Assumptions,
- Analytical Considerations,
- Supporting Data, and
- Other Information.

1. Assumptions

The analytical task of linking training, frequency, and productivity measures is based on several major assumptions relating to the data and the procedures followed to process the data. These assumptions include the following:

- An implicit assumption in this analysis is that the data being analyzed is accurate and complete. Problems with data recording and data entry could lead to biased or inaccurate data analyses. In spite of these possible inaccuracies in the data collection system, this study is based on information entered in the MDC system. Data which is verifiable as inaccurate is excluded from our analysis. All other data is included.

- Data entered in the MDC system is assumed to represent "successfully completed" work actions.

- Time of performance shown on MDC printouts for work actions is the elapsed time (difference between start and stop time). Time for breaks, meals, etc. is not included.

- Each member of a work center has an equal opportunity to perform a particular action. Thus, for all work performed, the calculations will use the total workers (with appropriate AFSC) in each work center.

- We can identify particular WUCs that are associated with actions taught using maintenance simulators. However, these WUCs are often very specific. In order to match this information with the level of detail obtained in our WUC-related data requests, we are assuming that associated higher level WUCs are also taught, in sufficient detail, on the SAMTs.

- If a maintenance simulator is supposed to be used in training, and an MTS is present at a base, then we are assuming that the SAMT is used in all appropriate training (we are not accounting for any simulator downtime).

2. Analytical Considerations

We have attempted to establish a relationship between work centers, WUC, and installation-level (FTD) training using

standard output data from base-level information systems (MDC and MMICS). We have tried to assess training effectiveness measured by the time documented to do a task. This disregards quality of work and assumes that all work was done correctly. Consequently, some biases may be incorporated in our work. A few are listed here.

- The task description for each WUC is very general for defining similar tasks. Difficulties encountered in tasks are not well defined by such descriptions as "remove and replace."

- Our interpretation of personnel awaiting FTD training is that they are untrained. Actually these personnel have received basic technical training in their AFSC and, in some cases, have job experience on other aircraft doing similar work. Because of this, our comparison of work centers shows large differences in numbers of untrained personnel and only small differences in time to perform work. Since we did not know which personnel in the work center did a specific job, we assumed all personnel could have done the job. This may be compensated for by the fact that we used average times for several jobs in the same work center.

- Record keeping for time spent on a task may vary from one work center to another. Although timekeeping is important, the requirement to document all time while at work may disguise how much time was actually spent on a particular job.

- Inter-wing comparisons may be biased by different FTD training, different approaches to using personnel, and different time-keeping procedures.

- The use of cross-training in mixed (more than one AFSC) work centers may also lead to biases in establishing the WUC-training relationship in this methodology.

3. Supporting Data

The details of our application are in Section III. We used information from the five wings listed below (full titles and persons interviewed are provided in Appendix A):

- Hill AFB, UT -- 388th TFW,
- Luke AFB, AZ -- 58th TTW,
- MacDill AFB, FL -- 56th TTW,
- Nellis AFB, NV -- 474th TFW, and
- Shaw AFB, SC -- 363rd TFW.

We requested six months of maintenance data for the period January through June 1983. This assured a sufficiently large amount of observations to support our analyses of these areas of maintenance: jet engine, flight control/instrumentation, and electrical power supply. We had a total of 3889 useable maintenance actions in this data set. This allowed us to make comparative analyses among forty-six work centers and five wings. Also, we made comparisons between two wings, the 58th TTW and 474th TFW, that trained in a different manner--one with simulators and one without simulators.

We received training information for all work centers included in our analysis for the same six month period. The training data was for each individual assigned, aggregated by work center.

4. <u>Other Information</u>

In the course of our research we attempted to gather data concerning two other aspects of maintenance and training. The first was the repair of components initially determined to be faulty and later determined upon retest to be all right. The second was the cost of SAMTs and the relationship to aircraft used for training.

a. Component Repair

During 1983, the Air Force instituted a review of depot repairables. This is an effort to determine which components that were determined by user organizations to be unserviceable and turned in to the depot for repair were found upon retest to be serviceable or "retest-okay" (RTOK). Details of the program are described in Air Force Logistics Command Regulation (AFLCR) 66-15, Equipment Maintenance Product Performance, 27 May 1983.

It was our intention to use these RTOK figures as another source of information that could be related to installation level training. We found that information was kept only for components where RTOK rates exceeded eight percent of turn-ins for the entire system. Another problem encountered was the inability to identify a high number of turn-ins by user organizations because of missing or incomplete turn-in tags. Also, many components are used in more than one type of aircraft located at the same installation; for example, the F-15 and F-16 both use the F-100 engine. Finally, in most cases the wing or base can be identified, but not the individual work center.

Because of these problems with imprecise data we did not pursue this line of research any further. Perhaps at some future time, when the RTOK review is over the initial stages of implementation, this particular type of analysis might prove to be useful.

b. Cost of SAMTs and Aircraft

In order to perfor. a cost comparison, we requested information on F-16 SAMT costs. The reason for this is that we found that wings having supporting FTDs with a full set of SAMTs were providing approximately one half less aircraft per month for training support than wings without SAMTs. Thus, it appears that the cost of a SAMT set may be compared with one half of an F-16 cost. The following cost figures were provided by the Air Force (AF/MPP). The simulator title and relationship to aircraft equipment and skills trained are shown in Section II.B.2.c. These costs are for SAMTs only and do not include hardware trainers which all wings have.

SAMT Number and	FY83 Cost ($)
2	$ 293,005
3	233,488
4	198,432
10	220,150
11	313,039
12	286,162
22	130,000
TOTAL	$1,674,276

Aircraft cost for the F-16 for FY83 is planned to be $2,254,600,000 for 120 planes or $18,788,333 each.[7] Thus, the $1,674,276 SAMT set produces a net cost avoidance of $7,719,891 for one-half aircraft needed for maintenance training.

D. METHODOLOGY

The methodology used for examining the linkage between FTD-provided training, specifically that training using SAMTs and

7/ Casper W. Weinberger, Annual Report to the Congress by DoD for FY86, Department of Defense, February 1983, p. 168.

hardware trainers, and maintenance productivity relies heavily on the work MCR accomplished in our previous research. The inference is that as the number of FTD-trained personnel in a work center increases, the productivity of that work center will increase. Productivity is measured in terms of the workhours used to complete a specific work action. Obviously, the complexity of work actions can vary even when a specific subassembly is being worked on and the action code used is fairly specific. This complexity or difference in work performed should be statistically smoothed by taking a large enough sample of particular types of work.

The following subsections will address three subjects:

- Determination of Training Status,
- Determination of Maintenance Productivity, and
- Analytical Techniques.

1. Determination of Training Status

The process of determining the training status of specific work centers involves obtaining the training requirements for the skills involved in performing the work, finding which individuals have received the required FTD course training, and calculating the overall work center training status. The procedure we followed in this task for calculating trained/untrained status is listed below.

- Determine which skills should be examined based on our experience in our prior work.
- Request course status summaries from each wing for the skills chosen for examination.

- Calculate trained/untrained personnel status for any work center that will be examined. The examination of specific work centers is determined by analysis of maintenance productivity information.

- The determination of whether a person is trained or untrained proceeds as follows:

  - If a person has taken the required FTD course for his AFSC, he is considered to be trained.

  - If a person has not taken the required FTD course for his AFSC, he is considered to be untrained.

- Calculate work center trained percentages for specific skills (AFSCs). When a work center contains only one AFSC, then the calculation consists of dividing the number of trained personnel by the total number of personnel in the work center. When a work center has more than one AFSC, then the calculation consists of dividing the number of trained personnel in the AFSC that pertains to the work performed by the total number of personnel having that particular AFSC in the work center.

2. Determination of Maintenance Productivity

The procedure for determining the maintenance productivity of specific work centers starts with the choice of specific work unit codes (WUCs) to be examined. This was assisted by our prior research in which we determined that there were three categories of maintenance with related skills that would be of interest: jet engines, flight control/ instrumentation, and electrical systems.

Having determined which WUCs were to be examined, a request to each wing for a specifically formatted report for a particular time period resulted in a large amount of information for use in our analyses. We were assisted greatly in our data request and formats by representatives of the Tactical Air Command (TAC), located at their headquarters, as well as TAC personnel at the wing level.

Our general procedure for determining work center maintenance productivity using the output data from the MDC system is as follows:

- Request a WUC report that specifies the WUCs required for analysis. The time period requested was January through June 1983. The report was requested for all work centers and for all action taken codes.

- After receipt of the WUC report from each wing, examine it for completeness. Then see which work centers have the appropriate AFSCs for the WUCs under consideration.

- Separate and aggregate the WUCs by work center and action taken code. Then sum to get total hours for each work center/action taken code. At this point, the analysis of maintenance productivity must incorporate other variables; i.e., total number of actions taken by each work center (frequency) and level of work center training. Number of workers and training information are received from other wing data bases.

- The final analytical step is to make comparisons among work centers to see what effects training and other measurable variables, in this instance frequency, have on maintenance productivity.

3. Analytical Techniques

The term analytical techniques means the integrated step-by-step process followed in analyzing the training and maintenance action data that we requested/received from five Air Force F-16 wings.

We used the following systems as our data sources:

- the MDC system and related CDS for F-16 maintenance, which provided maintenance information, and

- the training subsystem of the Maintenance Management Information and Control System (MMICS), which provided training information.

Special terms used in our analysis are defined below.

- Observation is a single completed work action in a work center.

- Frequency is the total number of work center observations (work actions) for the period examined.
- Productivity is the total number of workhours used to complete work action in a work center.

It is important to note that as the number of workhours increases productivity decreases. This is because we chose the standard industrial engineering definition for productivity--less time is better since it is the total time required to perform a task or produce an output. The alternative definition sometimes used is output per unit of time.

We used two techniques for examining the data:

- Examine productivity graphically to determine trends:
  - using wing-to-wing data for each WUC and its associated action codes,
  - using aggregated training effects for each WUC, and
  - using aggregated frequency effects (number of work actions) for each WUC.
- Use analysis of variance (ANOVA) to statistically test our sample results.

Each of these is discussed below.

a. <u>Examine Productivity Graphically to Determine Trends</u>

This technique involves:

- Aggregating the workhours for a specific WUC by action taken code ("action code") for each wing. Plotting this information and examining the overall relationship between training and productivity.
- Aggregating the workhours for each WUC by wing, separating the data by training status (percent trained) and frequency (number of work actions). Plotting the information and examining for aggregate training effects and aggregate frequency effects.

b. Use of ANOVA

This approach involves a statistical test of sample data to determine whether or not the results observed are statistically significant. The steps in this technique include:

- classification of all work center observations into "cells" in an ANOVA matrix, as shown on Exhibit II-5;
- computation of average productivity figures within each ANOVA matrix;
- computation of variation statistics attributable to:
  - training,
  - frequency (number of work actions), and
  - the error term; and
- performing an F-test for variable significance.

The choice of low, medium, and high classifications is dependent upon the training status (trained percent) of work centers and the number of observations (frequency) in the sample. The division into the various classification will vary from one WUC to another since training and frequency are different. Also the number of classifications may be increased (e.g., low, low-medium, high-medium, high) if the sample data allows for it in terms of sample size and distribution.

TRAINING \ FREQUENCY	LOW	MEDIUM	HIGH	ROW (TRAINING) TOTAL
LOW				
MEDIUM				
HIGH				
COLUMN (FREQUENCY) TOTAL				OVERALL TOTAL

Exhibit II-5. SAMPLE ANOVA MATRIX

III. APPLICATION OF METHODOLOGY AND RESULTS

We used two analytical techniques for our analysis. The first is quite elemental: the examination of graphical trends. A statistical method was used for the second--analysis of variance. This section discusses the following:

- Application of Methodology,
- Results, and
- Observations with respect to the results that were obtained.

A. APPLICATION OF METHODOLOGY

We chose three system WUCs for our analysis--each of which has a related AFSC or skill. This choice was based on the experience gained in our previous work and our knowledge that these would allow for a representation of total wing maintenance in key areas. These WUCs and their related AFSCs or skills are shown below.

WUC Number and Title	AFSC Number and Title
14000, Flight Control	326X7, Integrated Avionics Instrument and Flight Control System Specialist (F-16)
23000, Turbofan Power Plant	426X4, Jet Engine Technician (F-16)
42000, Electrical Power Supply	423X0, Aircraft Electrical Systems Technician (F-16)

We then requested workload data for these three WUCs from the five wings and at the same time requested training data for the three associated AFSCs. This data was aggregated by work

center and WUC actions. The aggregated data for each work center, showing average workhours per observation and frequency is provided in Appendix B, Backup Data. The WUC data and associated action codes, which had sufficient observations for our analysis, are shown below.

WORK UNIT CODE			
14000	23000	42000	ACTION CODE TITLE
		G	Repair/Replace Minor Parts
P	P	P	Removed
	Q		Installed
R	R	R	Removed and Replaced
T		T	Removed for Cannibalization
U		U	Replaced After Cannibalization
X	X	X	Test-Inspection-Service
Y	Y	Y	Troubleshoot

A statistical test was needed in order to make generalizations based on limited data. This test revealed whether there is a statistically significant difference in the observed mean productivity results as opposed to the observed differences simply being due to chance. One technique that allowed us to examine our variables is called analysis of variance (ANOVA). ANOVA tests the statistical significance of sample means or tests the null hypothesis that the sample means are equal. We have performed this test for both frequency (number of work actions) and training variables to determine their effect on productivity. A complete description of the ANOVA technique and its use, as well as the data we used, are provided in Appendix B, Backup Data.

The reminder of this section will discuss each of the three

system WUCs we examined and the related training status of the performing work centers:

- Flight Control,
- Turbofan Power Plant, and
- Electrical Power Supply.

1. Flight Control (WUC 14000)

The examination of productivity versus training status and frequency of work performance required the calculation of trained percent by individual work center, aggregated by wing (base), as well as the number of observations (frequency) for each action code. These data are shown on Exhibit III-1 for WUC 14000, which relates to AFSC 326X7. Similarly productivity by action code must be calculated; this is also shown on Exhibit III-1. The productivity (in workhours) by action code has been plotted and connected by lines on Exhibit III-2 for each wing (base). Each wing has a different amount of trained people. This exhibit is intended to shown any trend that may exist between training and productivity. Training effects are not readily apparent. For example, Hill AFB, with the lowest amount of trained personnel falls near the middle of other bases with higher amounts of trained personnel. Consequently, the use of frequency (number of work actions) must be introduced. Exhibit III-3 combines training and frequency with productivity data. This matrix combines all action code productivity data and displays training and frequency into general groupings of low to high. This same matrix will be used for ANOVA calculations later in our analysis.

BASE	TRAINING STATUS (% TRAINED)	ACTION CODE AVERAGE PRODUCTIVITY IN WORKHOURS					
		P	R	T	U	X	Y
HILL	43	4.5 (78)	10.2 (58)	4.3 (37)	5.1 (21)	6.3 (233)	11.5 (184)
LUKE	87	5.3 (6)	11.7 (16)	4.7 (14)	6.8 (10)	3.1 (7)	14.7 (14)
MACDILL	73	3.4 (37)	10.0 (116)	6.6 (47)	5.5 (44)	4.3 (42)	12.7 (72)
NELLIS	61	2.8 (13)	3.6 (31)	--------	--------	4.4 (27)	12.4 (43)
SHAW	77	3.0 (10)	6.4 (9)	2.6 (5)	2.8 (4)	6.3 (77)	12.8 (91)

NOTE: Numbers in parenthesis are the frequency (number of occurences) of the action codes.

Exhibit III-1. AGGREGATE AVERAGE PRODUCTIVITY AND FREQUENCY BY ACTION CODE (WUC 14000)

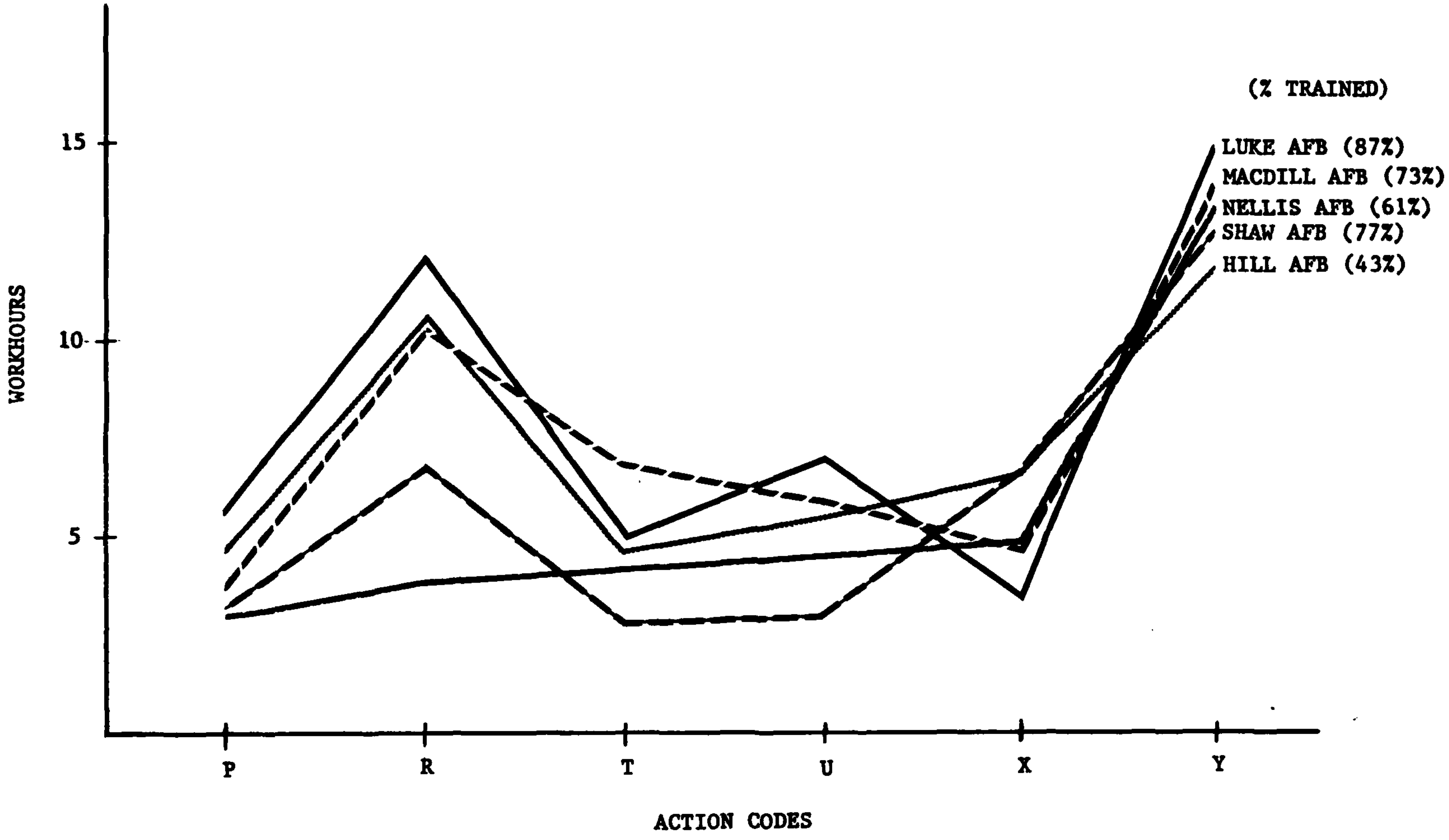

Exhibit III-2. TRAINING: WING-TO-WING (WUC 14000)

TRAINING \ FREQUENCY	LOW	MEDIUM	HIGH	ROW TOTAL
LOW	5.0	7.4	8.2	20.6
MEDIUM	6.5	5.0	8.9	20.4
HIGH	6.0	11.2	9.1	26.3
COLUMN TOTAL	17.5	23.6	26.2	67.3

Exhibit III-3. ANOVA MATRIX FOR WUC 14000

The aggregate frequency effects are shown on Exhibit III-4 and aggregate training effects on Exhibit III-5. The frequency effects are ambiguous and do not provide a great deal of information. Similarly, the training effects do not reveal any particular trend.

The other analytical technique is the application of ANOVA to our data. The same specific effects are seen in our ANOVA matrix (Exhibit III-3). The values go up and down moving from low to high training or frequency. The statistical ANOVA results are discussed in Section III.B., Results.

2. Turbofan Power Plant (WUC 23000)

As with the other system WUCs and related AFSCs, the calculation of training status and aggregation of productivity and frequency data was accomplished for WUC 23000 and its related AFSC 426X4. This information is shown on Exhibit III-6. The productivity by action code data has been plotted and connected on Exhibit III-7 for each wing (base) so as to show any trends that might be apparent.

Training effects in this instance are fairly evident: although the wing training status does not vary much, we do see sizable differences in productivity between the highest trained wings and the lowest. Exhibit III-8 combines training and frequency effects with productivity data. This matrix combines all action code productivity data and displays training and frequency as general groupings of low to high. We have used four frequency classifications due to the sample size (50 percent

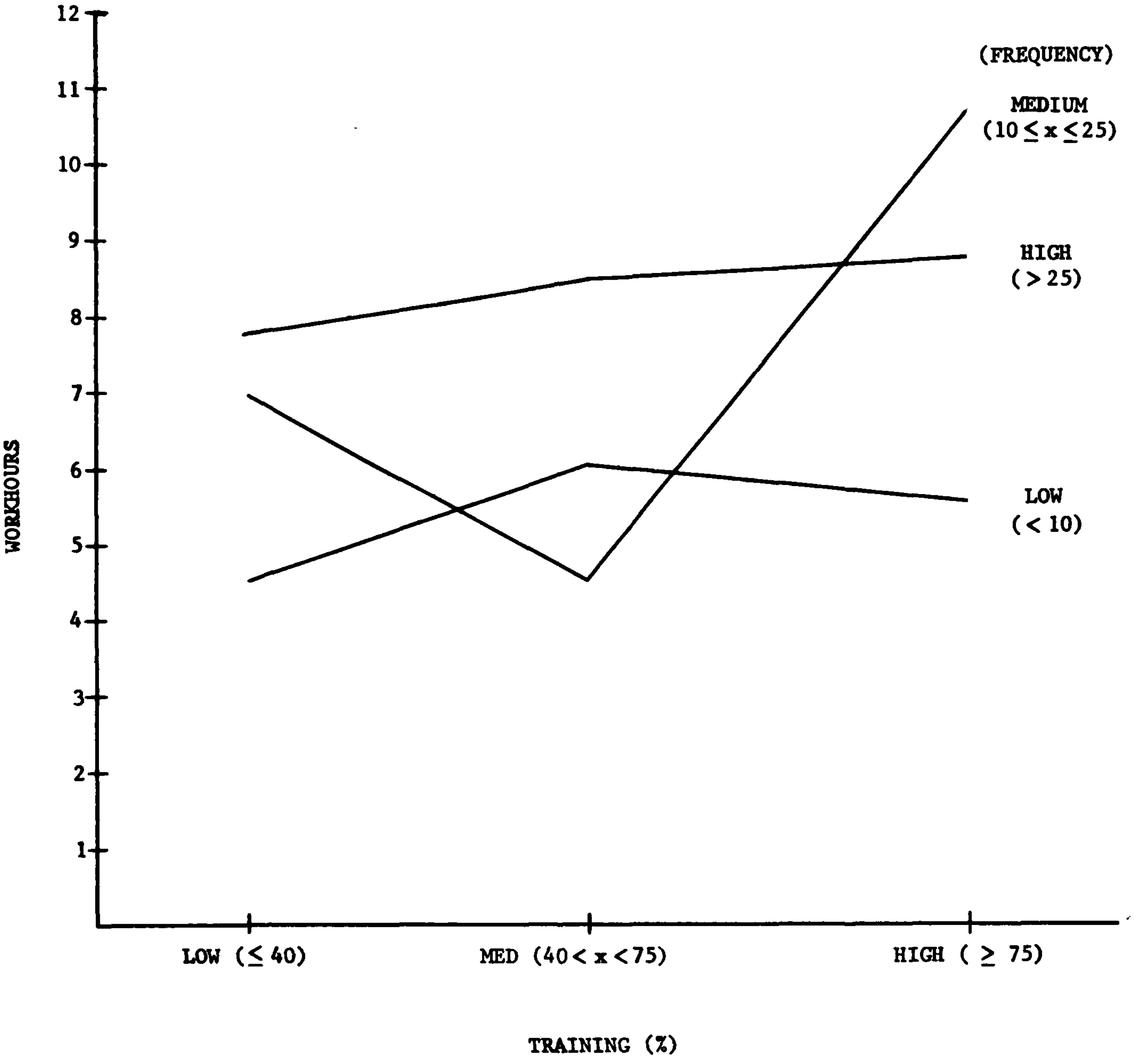

Exhibit III-4. AGGREGATE FREQUENCY EFFECTS (WUC 14000)

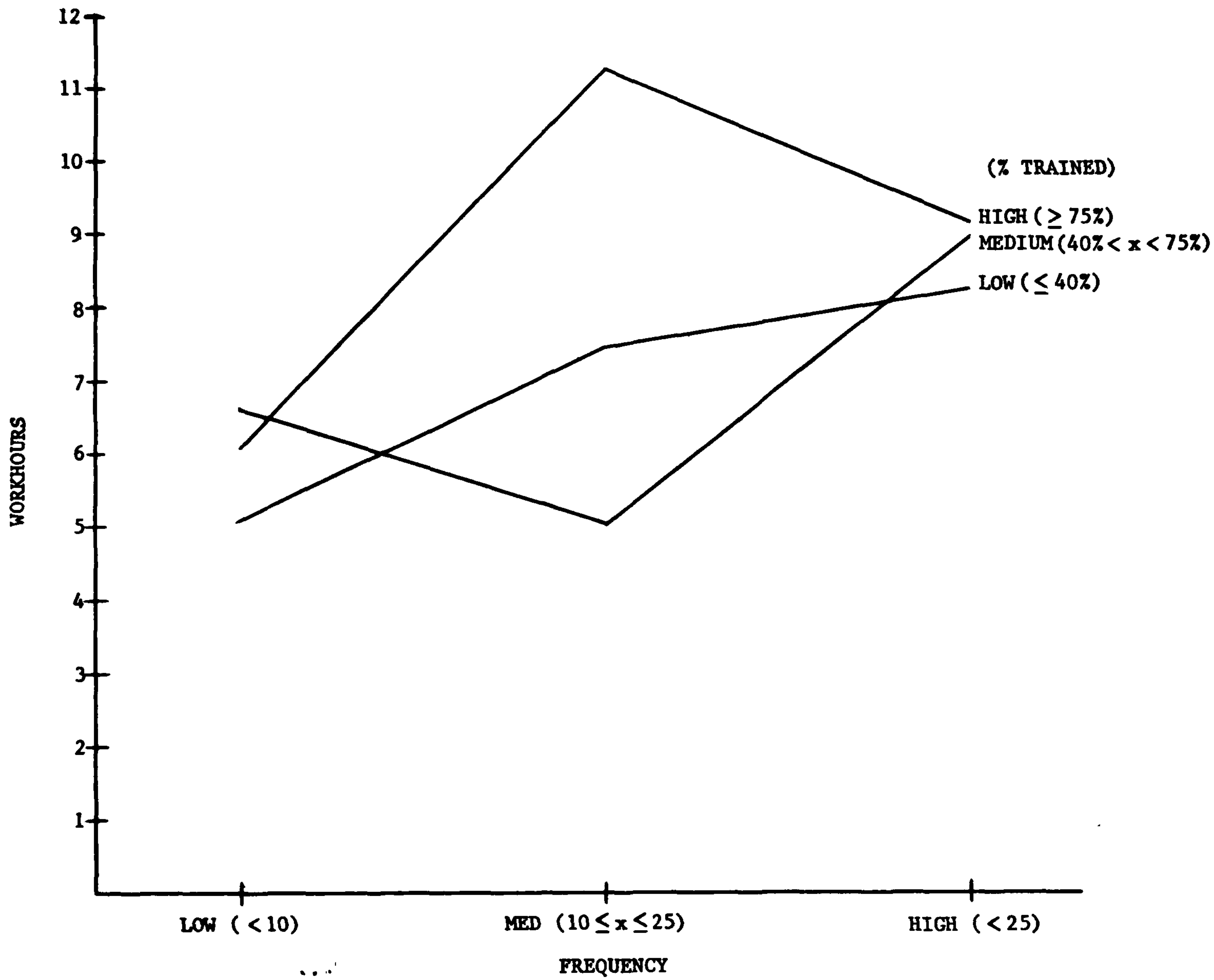

Exhibit III-5. AGGREGATE TRAINING EFFECTS (WUC 14000)

BASE	TRAINING STATUS (% TRAINED)	ACTION CODE AVERAGE PRODUCTIVITY (WORKHOURS)				
		P	Q	X	R	Y
HILL	61	17.7 (216)	19.0 (238)	8.8 (277)	17.0 (258)	13.0 (100)
LUKE	93	4.0 (59)	4.9 (57)	5.0 (43)	9.0 (3)	---------
MACDILL	79	12.6 (126)	10.5 (74)	8.2 (75)	14.2 (9)	9.4 (8)
NELLIS	72	16.3 (108)	17.5 (84)	13.9 (96)	25.9 (6)	14.5 (10)
SHAW	85	17.4 (23)	17.3 (24)	10.6 (12)	---------	---------

NOTE: Numbers in parenthesis are the frequency (number of occurences) of the action codes.

Exhibit III-6. AGGREGATE AVERAGE PRODUCTIVITY AND FREQUENCY BY ACTION CODE (WUC 23000)

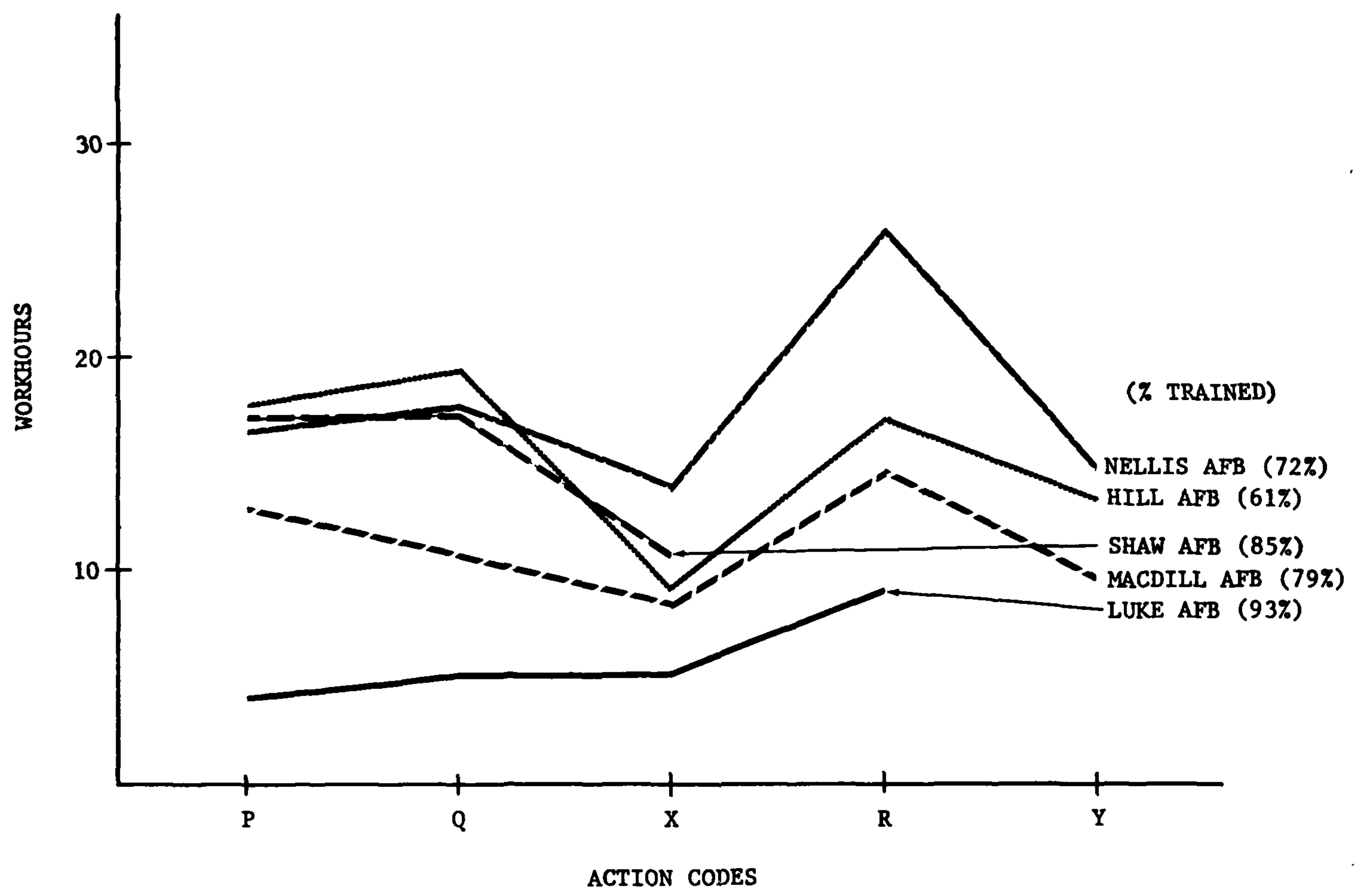

Exhibit III-7. TRAINING: WING-TO-WING (WUC 23000)

TRAINING \ FREQUENCY	LOW	MED-LOW	MED-HIGH	HIGH	ROW TOTAL
LOW	13.4	12.6	18.6	16.0	60.6
MEDIUM	17.9	14.0	16.4	14.0	62.3
HIGH	10.7	12.1	8.7	4.9	36.4
COLUMN TOTAL	42.0	38.7	43.7	34.9	159.3

Exhibit III-8. ANOVA MATRIX FOR WUC 23000

of our observations). This same matrix will be used for ANOVA calculations later in our analysis.

The aggregate frequency effects are shown on Exhibit III-9 and aggregate training effects on Exhibit III-10. The frequency effects show a trend of increasing productivity as frequency goes from low to high, although the medium-low and medium-high frequencies do not show this throughout. The same trend applies to training effects as well. Returning to Exhibit III-8, the specific effects are fairly evident since we can see a trend of increasing productivity as either training or frequency increase. The statistical ANOVA results are discussed in Section III.B., Results.

3. <u>Electrical Power Supply (WUC 42000)</u>

The productivity data by wing (base) for WUC 42000 and its related AFSC 423X0 has been aggregated by action code and is shown on Exhibit III-11. The plotted data has been connected so as to show any trends that might be evident on Exhibit III-12.

Training effects are evident. Although training status differences are not large there is a trend apparent of higher trained wings having performed more productively in most instances. Exhibit III-13 combines training and frequency effects with productivity data. This matrix combines all action code productivity data and displays training and frequency as general groupings of low to high. This same matrix will be used for ANOVA calculations later in our analysis.

The aggregate frequency effects are shown on Exhibit III-14 and aggregate training effects on Exhibit III-15. The

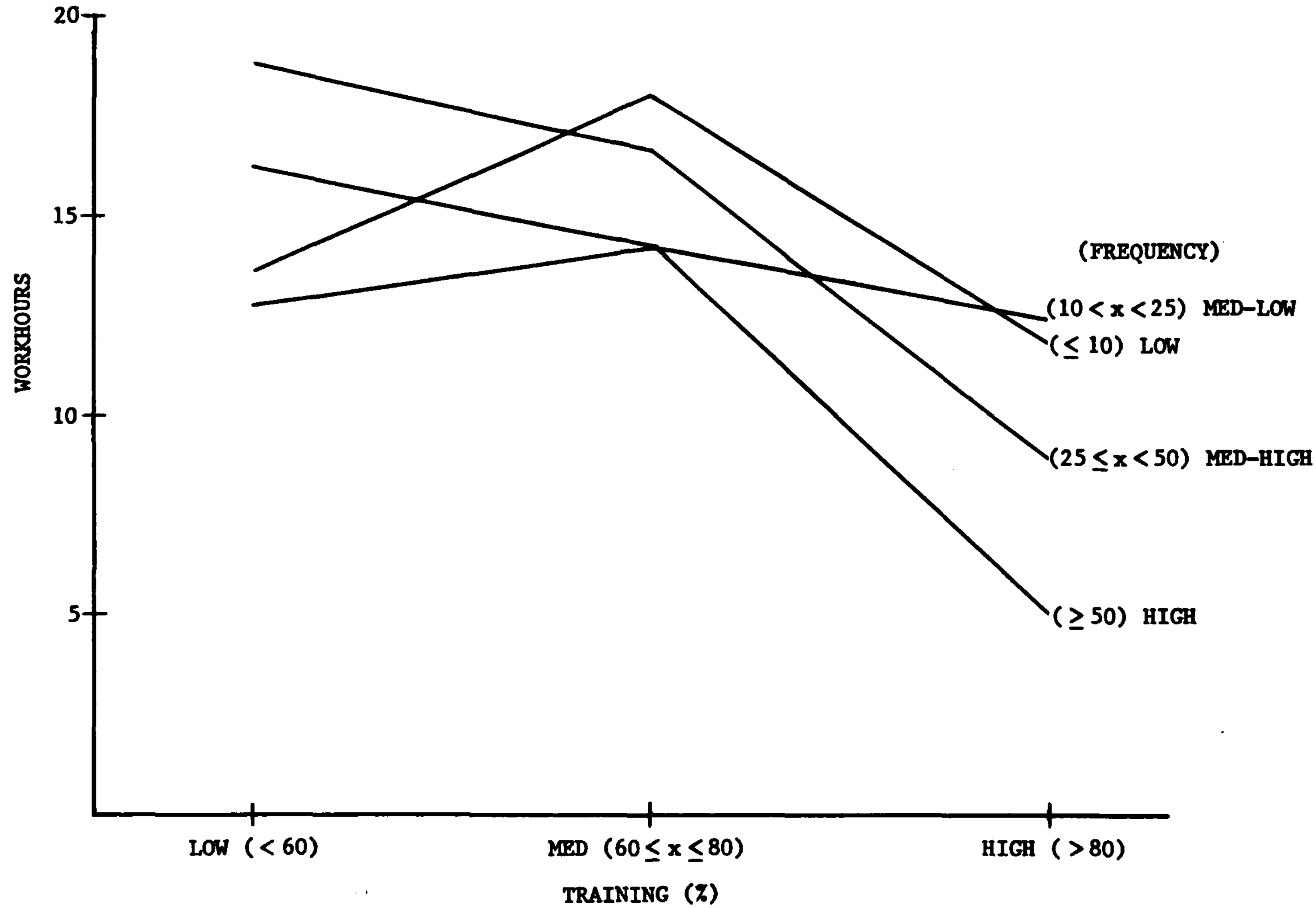

Exhibit III-9. AGGREGATE FREQUENCY EFFECTS (WUC 23000)

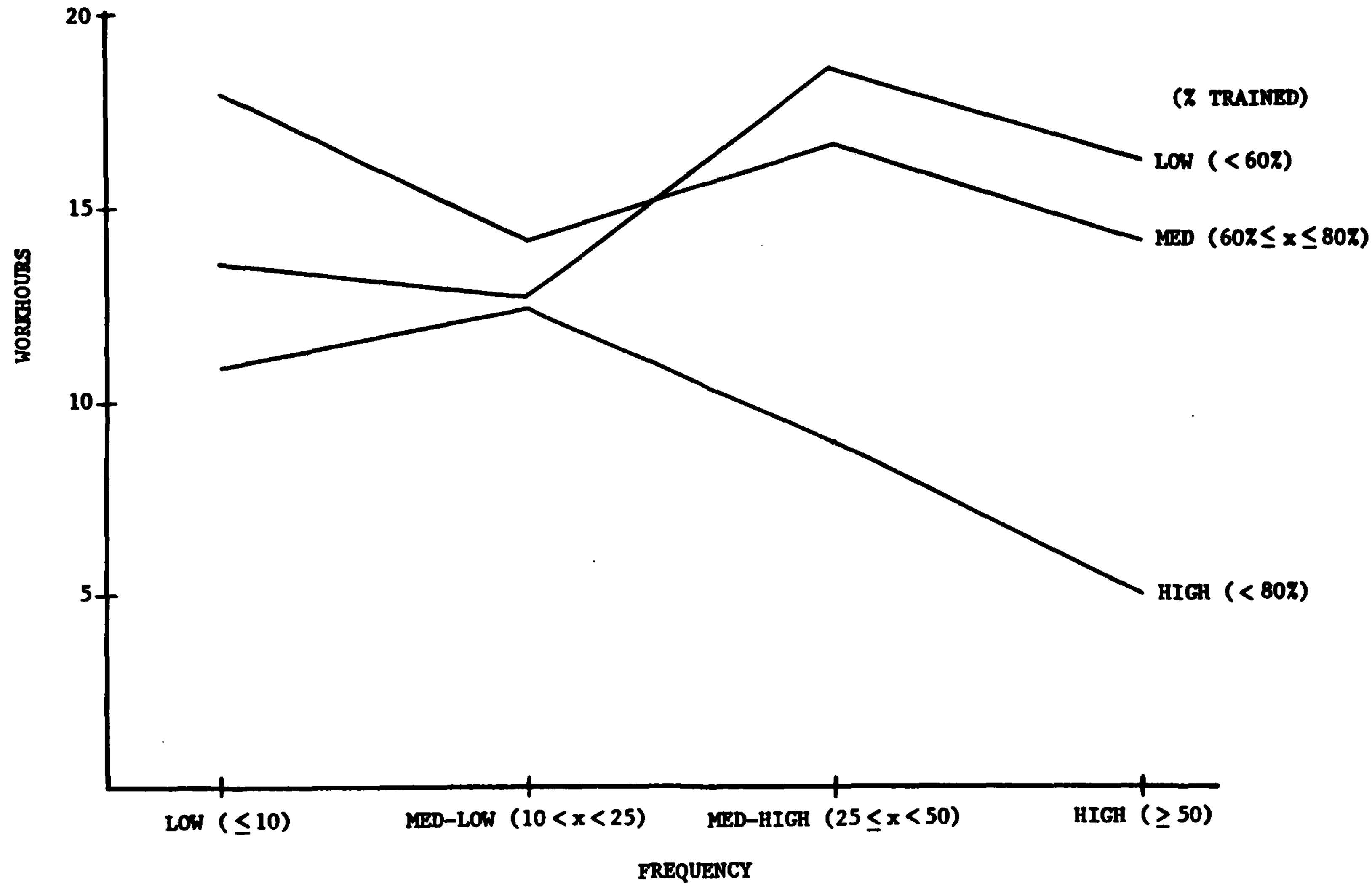

Exhibit III-10. AGGREGATE TRAINING EFFECTS (WUC 23000)

BASE	TRAINING STATUS (% TRAINED)	ACTION CODE AVERAGE PRODUCTIVITY (WORKHOURS)						
		G	P	R	T	U	X	Y
HILL	74	10.2 (19)	4.0 (37)	7.3 (59)	6.8 (52)	7.3 (38)	3.0 (60)	10.1 (35)
LUKE	87	5.3 (3)	3.7 (6)	11.8 (6)	--------	3.0 (2)	3.0 (2)	6.0 (1)
MACDILL	60	4.8 (13)	5.5 (15)	14.9 (26)	7.7 (45)	13.4 (39)	3.2 (17)	4.5 (7)
NELLIS	65	8.4 (9)	6.1 (5)	5.0 (71)	4.0 (3)	4.3 (6)	4.4 (13)	6.1 (19)
SHAW	85	6.6 (4)	1.5 (1)	7.5 (14)	0.5 (1)	--------	1.7 (10)	--------

NOTE: Numbers in parenthesis are the frequency (number of occurences) of the action codes.

Exhibit III-11. AGGREGATE AVERAGE PRODUCTIVITY AND FREQUENCY BY ACTION CODE (WUC 42000)

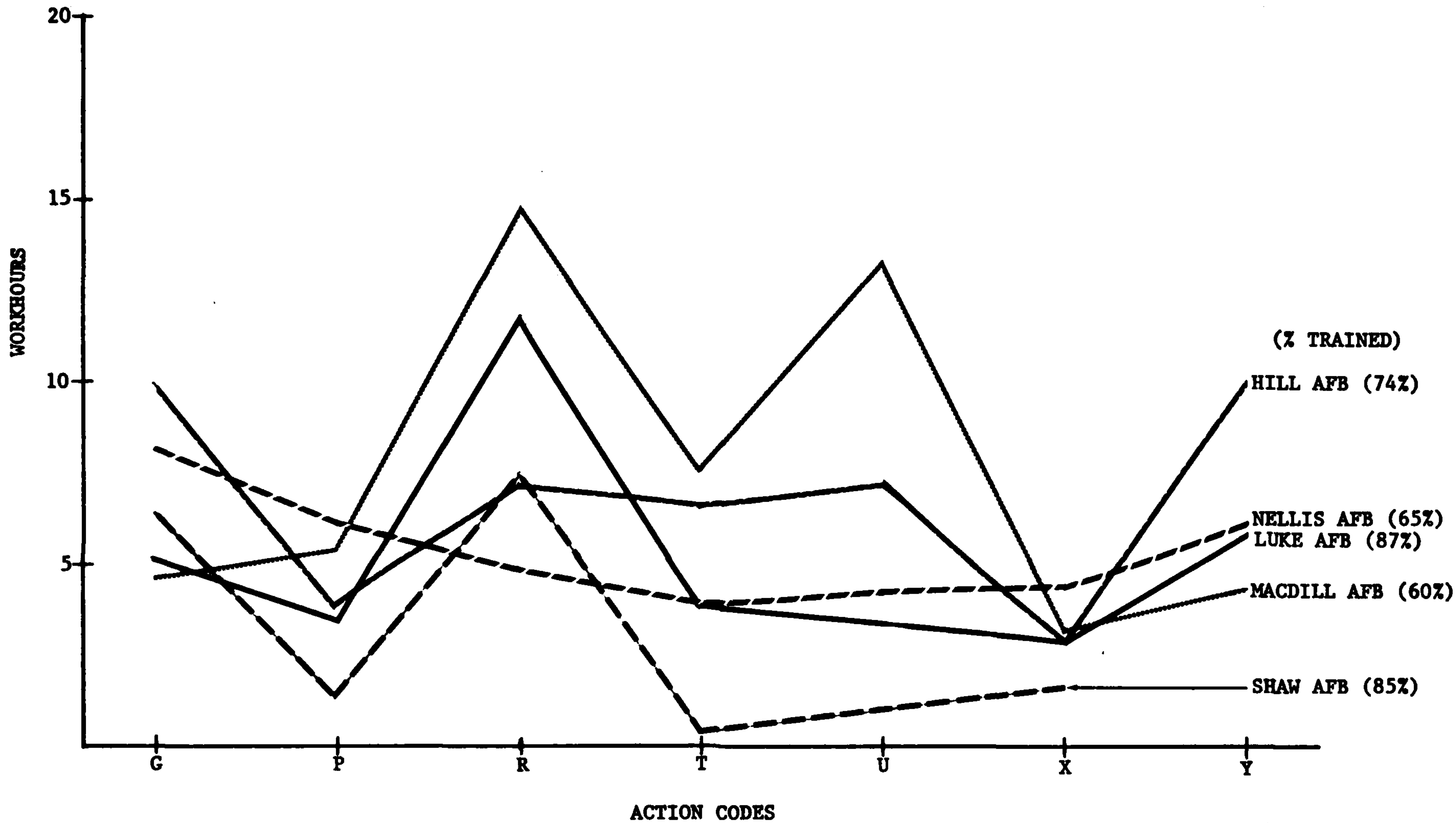

Exhibit III-12. TRAINING: WING-TO-WING (WUC 42000)

TRAINING \ FREQUENCY	LOW	MEDIUM	HIGH	ROW TOTAL
LOW	8.0	9.9	7.0	24.9
MEDIUM	6.3	5.2	5.0	16.5
HIGH	5.5	5.5	6.1	17.1
COLUMN TOTAL	19.8	20.6	18.1	58.5

Exhibit III-13. ANOVA MATRIX FOR WUC 42000

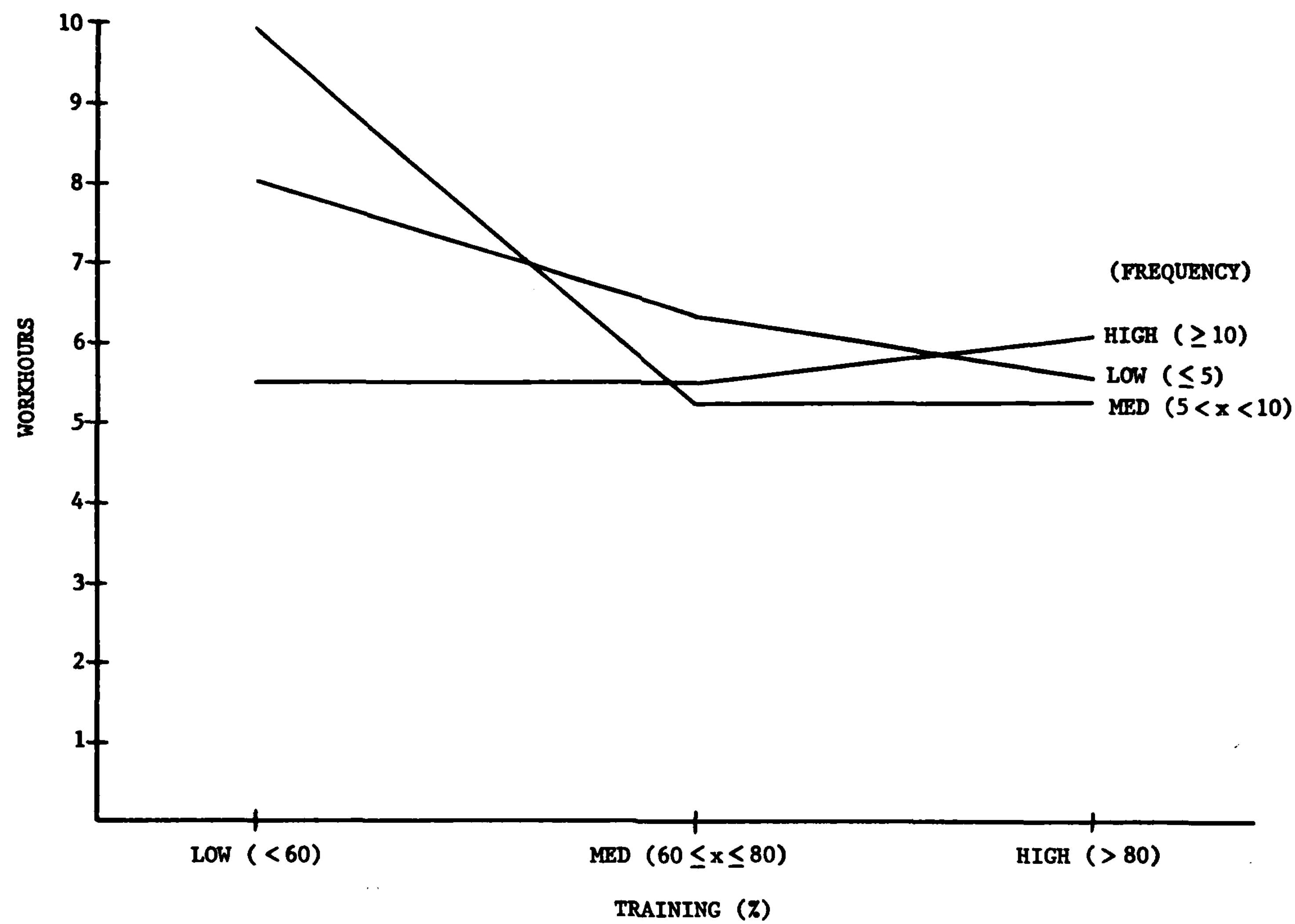

Exhibit III-14. AGGREGATE FREQUENCY EFFECTS (WUC 42000)

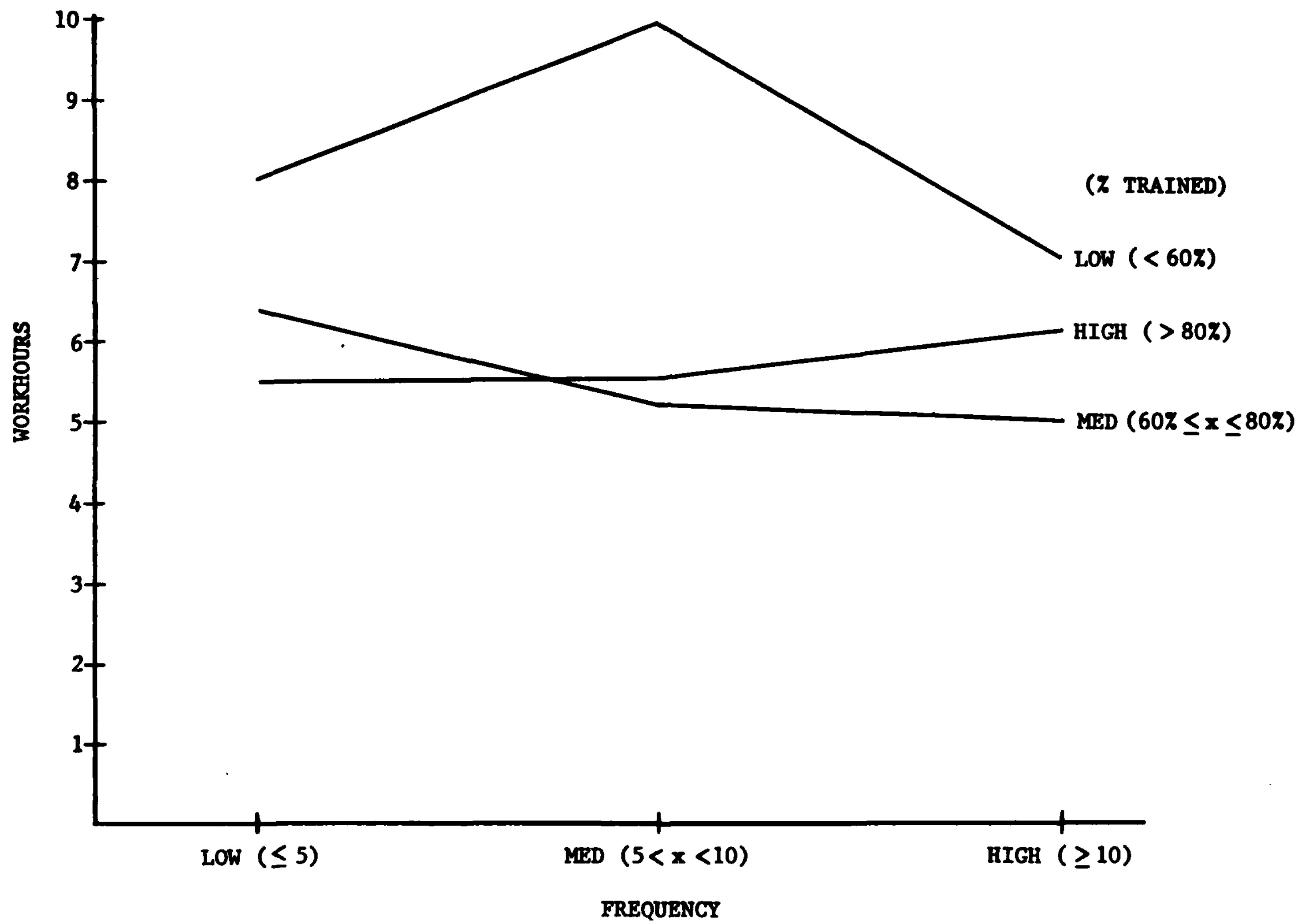

Exhibit III-15. AGGREGATE TRAINING EFFECTS (WUC 42000)

frequency effects are not consistent viewed from low to high although a positive trend is generally evident. The training effects are more apparent with a fairly consistent trend of increasing productivity shown between low and high trained. The statistical ANOVA results are discussed in Section III.B., Results.

B. RESULTS

In this section we will discuss the results we found in examining WUCs 14000, 23000, and 42000 across wings; specifically, by the application of ANOVA and the resulting statistics. Also, we will discuss other results we found by comparing statistics for Luke AFB and Nellis AFB.

1. Overall Results

In our present analysis, we have observed that varying frequency levels and different levels of training lead to different productivity. In particular, we have observed that the trend as either training percentage and frequency increase is for productivity to increase--fewer workhours used per maintenance action. Although this trend is observed for the data that was shown in the previous section, we are more concerned with the generalized result; is this trend one that we would expect to see throughout the Air Force.

In Section A, we developed ANOVA matrices for each of the WUCs examined. Although each specific action code represents a very different maintenance job, even within the same WUC, the

ANOVA matrices shown previously include all of the action codes included in this analysis for each WUC. This was done for two reasons. First, some action codes do not include enough work center observations to adequately represent a sample population to which an ANOVA analysis could be applied. Secondly, the rationale for accomplishing this kind of statistical analysis is to make some kind of inference about the general relationship that both training and frequency have to productivity. The inclusion of all action codes makes this a more general analysis.

Averages computed for each cell in the matrices can be combined to illustrate what are known as the "specific effects" of both training and frequency. These effects illustrate the change in the average productivity value as either training or frequency change. Because cell averages include all action codes for each WUC in our analysis, the specific effects of training and frequency for WUCs provide an indication of productivity trends as either frequency or training change by themselves.

Exhibits III-16, III-17, and III-18 summarize the statistics developed for WUCs 14000, 23000, and 42000. The pertinent comparative statistics in these tables are F-statistics for training (F_T) and frequency (F_F). Comparing these statistics with standard F-values, derived from the F-distribution at a specific level of confidence, allows us to draw conclusions as to the statistical validity of our results. Specifically, if the F-statistics shown on Exhibits III-16, III-17, and III-18 are larger than the appropriate F-values from the standard F-distribution, then we can conclude that the relationships we observed

VARIATION	DEGREES OF FREEDOM (D.F.)	MEAN SQUARES	F-STATISTIC	F-VALUE
TRAINING V_T	2	3.7 $\left(\hat{S}_T^2 = \frac{V_T}{D.F._T}\right)$	1.09 $\left(F_T = \frac{\hat{S}_T^2}{\hat{S}_E^2}\right)$	4.32 (90% Confidence Level)
FREQUENCY V_F	2	6.7 $\left(\hat{S}_F^2 = \frac{V_F}{D.F._F}\right)$	1.97 $\left(F_F = \frac{\hat{S}_F^2}{\hat{S}_E^2}\right)$	4.32 (90% Confidence Level)
ERROR V_E	4	3.4 $\left(\hat{S}_E^2 = \frac{V_E}{D.F._E}\right)$		

Exhibit III-16. ANOVA TABLE FOR WUC 14000

VARIATION	DEGREES OF FREEDOM (D.F.)	MEAN SQUARES	F-STATISTIC	F-VALUE
TRAINING V_T	2	52.5 $\left(\hat{S}_T^2 = \frac{V_T}{D.F._F}\right)$	6.73 $\left(F_T = \frac{\hat{S}_T^2}{\hat{S}_E^2}\right)$	3.46 (90% Confidence Level)
FREQUENCY V_F	3	5.0 $\left(\hat{S}_F^2 = \frac{V_F}{D.F._F}\right)$	.64 $\left(F_F = \frac{\hat{S}_F^2}{\hat{S}_E^2}\right)$	3.29 (90% Confidence Level)
ERROR V_E	6	7.8 $\left(\hat{S}_E^2 = \frac{V_E}{D.F._E}\right)$		

Exhibit III-17. ANOVA TABLE FOR WUC 23000

VARIATION	DEGREES OF FREEDOM (D.F.)	MEAN SQUARES	F-STATISTIC	F-VALUE
TRAINING V_T	2	7.3 $\left(\hat{S}^2_T = \frac{V_T}{D.F._T}\right)$	6.35 $\left(F_T = \frac{\hat{S}^2_T}{\hat{S}^2_E}\right)$	4.32 (90% Confidence Level)
FREQUENCY V_F	2	.5 $\left(\hat{S}^2_F = \frac{V_F}{D.F._F}\right)$	.43 $\left(F_F = \frac{\hat{S}^2_F}{\hat{S}^2_E}\right)$	4.32 (90% Confidence Level)
ERROR V_E	4	1.15 $\left(\hat{S}^2_E = \frac{V_E}{D.F._E}\right)$		

Exhibit III-18. ANOVA TABLE FOR WUC 42000

represent Air Force maintenance and training in general: training increases productivity. However, in order to find similar results at other bases for which we do not have data there should be no significant changes in work load, management procedures, etc. Additional research with other types of training and maintenance should be checked.

The appropriate test results for each WUC training and frequency variables are provided below:

<u>14000</u>

- Training
  - F-statistic (training) is 1.09;
  - F-value (from F-distribution, 90% confidence, 2 degrees of freedom (d.f.) for training variance, 4 d.f. for error variance is 4.32;
  - 1.09 is less than 4.32, so the relationship between training and productivity in WUC 14000 <u>does not</u> indicate, at the 90% confidence level, that training has a positive impact on productivity; and
  - at the 75% confidence level the F-value is 2.0 so we see that training has a positive impact only at a very low level of confidence.
- Frequency
  - F-statistic (frequency) = 1.97;
  - F-value (from F-distribution, 90% confidence, 2 d.f. for frequency variance, 4 d.f. for error variance) = 4.32;
  - 1.97 is less than 4.32, so the relationship between frequency and productivity in WUC 14000 <u>does not</u> indicate, at the 90% confidence level, that frequency has a positive impact on productivity; and
  - at the 75% confidence level the F-value is 2.0 so we see that frequency does have a positive impact at this lower level of confidence.

23000

- Training

  - F-statistic (training) = 6.73;

  - F-value (from F-distribution, 90% confidence, 2 d.f. for training variance, 6 d.f. for error variance) = 3.46;

  - 6.73 is greater than 3.46, so the relationship between training and productivity in WUC 23000 does indicate, at the 90% confidence level, that training has a positive impact on productivity; and

  - at the 95% confidence level the F-value is 5.14 so we see that training has a positive impact at a fairly high level of confidence.

- Frequency

  - F-statistic (frequency) = .64;

  - F-value (from F-distribution, 90% confidence, 3 d.f. for frequency variance, 6 d.f. for error variance) = 3.29;

  - .64 is less than 3.29, so the relationship between frequency and productivity in WUC 23000 does not indicate, at the 90% confidence level, that frequency has a positive impact on productivity; and

  - frequency appears to have a positive impact only at a very low level of confidence.

42000

- Training

  - F-statistic (training) = 6.35;

  - F-value (from F-distribution, 90% confidence, 2 d.f. for training variance, 4 d.f. for error variance) = 4.32;

  - 6.35 is greater than 4.32, so the relationship between training and productivity in WUC 42000 does indicate, at the 90% confidence level, that training has a positive impact on productivity; and

- at the 95% confidence level the F-value is 6.94 so we see that training has a positive impact at a fairly high level of confidence.

- Frequency

  - F-statistic (frequency) = .43;

  - F-value (from F-distribution, 90% confidence, 2 d.f. for frequency variance, 4 d.f. for error variance) = 4.32;

  - .43 is less than 4.32, so the relationship between frequency and productivity in WUC 42000 does not indicate, at the 90% confidence level, that frequency has a positive impact on productivity; and

  - frequency appears to have a positive impact only at a very low level of confidence.

2. Other Results

We undertook a comparison of Luke AFB and Nellis AFB so that we could examine what effect simulators (SAMTs) had on productivity as well as the savings simulators provided. First, we combined the WUC data for Luke AFB and Nellis AFB for all WUCs we looked at (14000, 23000, 42000). This combined productivity data, with training and frequency effects, is shown on the ANOVA matrix on Exhibit III-19. It is evident from this display that Luke which had a higher training percentage than Nellis is also slightly more productive. Luke was 89 percent trained and Nellis was 66 percent trained overall.

Next, we calculated ANOVA statistics. The statistics we used are summarized on Exhibit III-20, the ANOVA table for Luke and Nellis comparison. We found the following results for the training and frequency variables:

TRAINING \ FREQUENCY	LOW	MEDIUM	HIGH	ROW TOTAL
NELLIS (No SAMTs)	28.0	27.1	25.9	81.0
LUKE (SAMTs)	22.2	26.1	20.8	69.1
COLUMN TOTAL	50.2	53.2	46.7	150.1

Exhibit III-19. ANOVA MATRIX FOR LUKE AFB AND NELLIS AFB FOR COMBINED WUCS

VARIATION	DEGREES OF FREEDOM (D.F.)	MEAN SQUARES	F-STATISTIC	F-VALUE
TRAINING V_T	1	23.6 $\left(\hat{S}_T^2 = \frac{V_T}{D.F._T}\right)$	7.02 $\left(F_T = \frac{\hat{S}_T^2}{\hat{S}_E^2}\right)$	8.53 (90% Confidence Level)
FREQUENCY V_F	2	5.29 $\left(\hat{S}_F^2 = \frac{V_F}{D.F._F}\right)$	1.57 $\left(F_F = \frac{\hat{S}_F^2}{\hat{S}_E^2}\right)$	9.0 (90% Confidence Level)
ERROR V_E	2	3.36 $\left(\hat{S}_E^2 = \frac{V_E}{D.F._E}\right)$		

Exhibit III-20. ANOVA TABLE FOR COMBINED WUCS FOR LUKE AFB AND NELLIS AFB

- Training
  - F-statistic (training) = 7.02;
  - F-value = 8.53 (90% confidence); 2.57 (75% confidence)
  - 7.02 is less than 8.53 but greater than 2.57 thus we do not find a high level of confidence in the impact of training on productivity comparing the two bases.
- Frequency
  - F-statistic (frequency) = 1.57;
  - F-value = 9.0 (90% confidence, 3.0 (75% confidence);
  - 1.57 is less than 9.0 (and less than 3.0) thus we find a very low level of confidence of the impact of frequency comparing the two bases.

Thus Luke, which is 23 percent better trained than Nellis, and produced higher productivity results was not significantly better in a statistical sense. However, considering that SAMTs were used at Luke and not used at Nellis, we find that no negative effect is apparent from the use of simulators, rather than real aircraft, for maintenance training.

In the last section we provided the overall cost of a SAMT set, that supports a wing, as $1,674,276 in FY83 dollars. This SAMT allows a supported wing to provide one-half less aircraft per month on a continuing basis, which is one-half of $18,788,333 or $9,394,167. Thus, the SAMTs avoid $7,719,891 in costs per wing supported.

C. OBSERVATIONS

Our overall intention of showing a relationship of training

to maintenance productivity was successful and provides quantified data to support the conclusion that installation level training increases productivity. The graphic representations of frequency and training versus productivity lead us to the conclusion that there is a positive relationship between training and productivity at the installation level. The statistical results using ANOVA indicate that for WUC 23000 and its related AFSC, as well as for WUC 42000 and its related AFSC, our data is representative of the overall Air Force maintenance population at the 90 percent confidence level or higher. This is not true of our ANOVA result for WUC 14000, and its related AFSC, although we did find a positive relationship existed. The results mean that similar results would be found at other bases for which data was not collected; provided there are no significant changes in work load, management procedures, and so forth. Additional research will see if these results are valid.

We found in our comparison of the two wings located at Luke AFB and Nellis AFB that the wing that was trained using SAMTs at Luke performed maintenance as productively as the wing at Nellis that was trained without SAMTs. This was accomplished with a savings of approximately one-half aircraft assigned to support training throughout the period observed. The cost savings encountered here lead to the conclusion that SAMTs save money and improve readiness by allowing additional assigned aircraft to be used for operational purposes.

It is apparent from our expanded research in this phase that the interim results previously experienced have been reinforced

by our current analysis. It is shown that training does directly influence maintenance and that delaying the training of new maintenance personnel is detrimental to productivity. The wing analysis and training sections are not presently attempting this linkage of training and maintenance since their primary concerns are to improve operational flying capability. Thus, statistics or data are maintained and training is conducted but the two are not being correlated. If wing headquarters personnel were able to do analyses similar to ours, they should be able to show where training needs reinforcement so as to positively affect maintenance.

Although it was not stressed during our previous discussion, there are some maintenance data collection improvements that could benefit the current system and assist analysis at the wing level. The first would be the entry of employee number for all maintenance crew personnel on the AFTO Form 349 for entry in the MDC system. This would allow direct and precise measurements of training and productivity for individuals and work centers. Assurance that the use of employee number does not interfere with individual privacy rights must be considered. It appears it does not. Legal advice should be sought before implementation.

A second improvement would be a greater use of component level WUCs for maintenance reporting rather than system or subsystem WUCs. This would allow more refined analysis to be performed and would more precisely define what work is being done. Finally, the current set of action taken codes does not sufficiently define what maintenance tasks are being performed.

This is only pertinent when applied to higher level, system or subsystem, WUCs. If component level WUCs were always used then the current action taken codes would prove to be adequate.

APPENDIX A

REFERENCE SOURCES

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Rodney D. McConnell et al., Skill Training Analysis: The Linkage of Unit Level Skill Training and Unit Productivity; TR-8202-1; Management Consulting & Research, Inc.; 14 June 1983.

B. INTERVIEWS

Name	Organization	Telephone #
HQ Air Force Staff: Washington D.C.		
		(AV-22X-XXXX) or (202) 69X-XXXX
Lt Col Stanley Goralski	AF/LEYM	7-1431
Capt Alfred Rodriguez	AF/MPP	5-7321
Maj John Smith	AF/LEYYC	7-4377

Name	Organization	Telephone #
TAC HQ: Langley AFB, VA		(AV 432-XXXX) or (804) 764-XXXX
Lt Col Kent Burns	TAC/LGQT	3688
Air Force Logistics Command: Wright-Patterson AFB, OH		(AV 787-XXXX) or (513) 257-XXXX
Mr. Charles Cook	AFLC/MMEMG	4896
56th Tactical Training Wing: MacDill AFB, FL		(AV 968-XXXX) or (813) 830-XXXX
MSgt Harris	MAT	3212
Sgt Stetler	Analysis	4708
58th Tactical Training Wing: Luke AFB, AZ		(AV 853-XXXX) or (602) 856-XXXX
TSgt Howard Schultz	MAT	3228
CMSgt Eliezer Levine	FTD 527	7148
MSgt Arthur Kassel	Analysis	6759
MSgt Gormiller	310th AMU	----
Sgt Gurney	310th AMU	----
MSgt Magee	311th AMU	----
MSgt Siperek	311th AMU	----
363rd Tactical Fighter Wing: Shaw AFB, SC		(AV 965-XXXX) or (803) 787-XXXX
TSgt Michael Shaulis	MAT	3188
388th Tactical Fighter Wing: Hill AFB, UT		(AV 458-XXXX) or (801) 777-XXXX
Lt Col Carl Bayha	MAT	3835
Sgt Bigham	Analysis	3529
474th Tactical Fighter Wing: Nellis AFB, NV		(AV 682-XXXX) or (702) 643-XXXX
Maj David Crews	MAT	2213
TSgt David Kurau	MAT	2216
MSgt Gary Hollis	Analysis	3108
MSgt Alfred Siqueido	FTD 523	2670
CMSgt Klein	428th AMU	----
Sgt Green	428th AMU	----
CMSgt Anderson	430th AMU	4648
TSgt Medina	430th AMU	4648
Institute for Defense Analyses: Alexandria, VA		
Dr. Jesse Orlansky		(703) 845-2293
Honeywell Inc.: West Covina, CA		
Dr. Ruth Weinclaw		(213) 331-0011

APPENDIX B

This Appendix contains:

- Productivity and frequency data, and
- Analysis of variance technique.

PRODUCTIVITY AND FREQUENCY DATA

APPENDIX B

BACKUP DATA

AVERAGE WORKHOURS PER OBSERVATION (FREQUENCY)
14000

BASE AND WORK CENTER	NO. OF WORKERS (% TRAINED)	ACTION CODES						TOTAL
		P	R	T	U	X	Y	
HILL AFB	66 (43)	4.5 (37)	10.2 (58)	4.3 (37)	5.1 (21)	6.3 (233)	11.5 (184)	7.8 (611)
TG 12H	21 (66)	3.5 (23)	4.5 (14)	3.0 (4)	3.4 (3)	3.6 (22)	7.6 (29)	
TG 12N	10 (40)	9.9 (8)	3.4 (5)	--	--	5.8 (15)	8.7 (11)	
TG 12B	18 (13)	3.1 (33)	12.1 (24)	2.6 (14)	2.5 (8)	6.5 (66)	14.8 (76)	
TG 12S	17 (39)	6.5 (14)	14.8 (15)	5.8 (19)	7.6 (10)	6.7 (130)	10.0 (68)	
MACDILL AFB	33 (73)	3.4 (37)	10.0 (116)	6.6 (47)	5.5 (44)	4.3 (42)	12.7 (72)	8.2 (358)
EG 121	8 (78)	3.4 (5)	9.0 (38)	4.0 (14)	3.8 (8)	6.7 (6)	14.5 (16)	
EG 123	9 (72)	3.3 (12)	7.3 (19)	3.1 (7)	3.4 (11)	16.0 (1)	5.0 (4)	
EG 125	8 (70)	10.2 (3)	14.4 (31)	12.6 (16)	12.2 (12)	10.3 (2)	15.1 (8)	
EG 127	8 (72)	2.2 (17)	8.3 (28)	3.2 (10)	2.2 (13)	3.2 (33)	12.3 (44)	
NELLIS AFB	28 (61)	2.8 (13)	3.6 (31)	--	--	4.4 (27)	12.4 (43)	7.0 (114)
NG 121	9 (51)	--	4.3 (10)	--	--	1.9 (2)	5.5 (5)	
NG 123	11 (91)	3.0 (1)	2.6 (13)	--	--	4.6 (25)	13.6 (37)	
NG 125	8 (35)	2.8 (12)	4.4 (8)	--	--	--	2.0 (1)	
LUKE AFB	23 (87)	5.3 (6)	11.7 (16)	4.7 (14)	6.8 (10)	3.1 (7)	14.7 (14)	8.7 (67)
7G 12A	12 (100)	8.3 (2)	12.7 (14)	5.1 (8)	8.7 (7)	5.0 (2)	18.6 (4)	
7G 120	11 (75)	3.8 (4)	5.0 (2)	4.2 (6)	2.3 (3)	2.4 (5)	13.1 (10)	
SHAW AFB	30 (77)	3.0 (10)	6.4 (9)	2.6 (5)	2.8 (4)	6.3 (77)	12.8 (91)	9.0 (196)
2G 12H	12 (67)	3.0 (10)	5.8 (4)	2.8 (4)	2.8 (4)	5.7 (71)	10.6 (71)	
2G 12J	18 (83)	--	6.8 (5)	2.0 (1)	--	12.8 (6)	20.5 (20)	
TOTAL	180 (63)	4.0 (144)	9.2 (230)	5.3 (103)	5.4 (79)	5.9 (386)	12.2 (404)	8.1 (1346)

AVERAGE WORKHOURS PER OBSERVATION (FREQUENCY)
42000

BASE AND WORK CENTER	NO. OF WORKERS (% TRAINED)	ACTION CODES							TOTAL
		G	P	R	T	U	X	Y	
HILL AFB	39 (74)	10.2 (19)	4.0 (37)	7.3 (59)	6.8 (52)	7.3 (38)	3.0 (60)	10.1 (35)	6.5 (300)
TG 12J	12 (89)	11.3 (4)	6.0 (1)	3.3 (15)	3.9 (8)	3.8 (8)	2.4 (18)	7.9 (15)	
TG 12P	9 (44)	9.2 (6)	3.3 (16)	10.4 (9)	11.5 (2)	8.5 (4)	1.9 (9)	21.0 (3)	
TH 12C	9 (78)	10.0 (1)	3.0 (6)	8.8 (17)	6.9 (17)	6.1 (10)	2.3 (7)	6.9 (6)	
TH 12T	9 (89)	10.5 (8)	5.1 (14)	7.6 (18)	7.3 (25)	9.6 (16)	4.0 (26)	12.0 (11)	
MACDILL AFB	30 (60)	4.8 (13)	5.5 (15)	14.9 (26)	7.7 (45)	13.4 (39)	3.2 (17)	4.5 (7)	9.2 (162)
EG 121	7 (57)	6.3 (6)	3.8 (6)	7.1 (7)	16.5 (2)	16.5 (2)	6.8 (4)	8.0 (1)	
EG 123	8 (50)	—	10.0 (2)	13.1 (8)	9.5 (15)	8.6 (12)	4.0 (1)	—	
EG 125	7 (57)	1.0 (1)	6.6 (3)	27.0 (8)	7.8 (16)	8.9 (19)	—	4.0 (1)	
EG 127	8 (75)	3.9 (6)	4.8 (4)	6.0 (3)	3.7 (12)	4.3 (6)	2.0 (12)	3.9 (5)	
NELLIS AFB	34 (65)	8.4 (9)	6.1 (5)	5.0 (71)	4.0 (3)	4.3 (6)	4.4 (13)	6.1 (19)	5.3 (126)
NG 121	9 (22)	2.0 (1)	—	3.9 (26)	4.0 (3)	5.8 (3)	3.6 (5)	7.0 (3)	
NG 123	7 (94)	2.8 (1)	2.5 (1)	2.5 (32)	—	2.7 (3)	2.8 (5)	4.6 (5)	
NG 125	9 (89)	4.8 (1)	—	5.3 (13)	—	—	8.3 (2)	5.9 (10)	
NG 160	9 (67)	11.0 (6)	7.0 (4)	3.4 (31)	—	—	8.0 (1)	12.0 (1)	
LUKE AFB	15 (87)	5.3 (3)	3.7 (6)	11.8 (6)	4.0 (1)	—	3.0 (2)	6.0 (1)	6.6 (19)
7G 12A	8 (100)	5.3 (3)	3.7 (6)	15.0 (3)	4.0 (1)	—	1.0 (1)	6.0 (1)	
7G 120	7 (71)	—	—	8.5 (3)	—	—	5.0 (1)	—	
SHAW AFB	13 (85)	6.6 (4)	1.5 (1)	7.5 (14)	0.5 (1)	—	1.7 (10)	—	5.0 (30)
2G 12H	6 (67)	4.0 (1)	—	7.3 (11)	0.5 (1)	—	1.7 (10)	—	
2G 12J	7 (100)	7.5 (3)	1.5 (1)	8.0 (3)	—	—	—	—	
TOTAL	131 (71)	7.8 (48)	4.5 (64)	7.7 (176)	7.0 (102)	9.9 (83)	3.1 (102)	8.2 (62)	6.9 (637)

ANALYSIS OF VARIANCE

ANALYSIS OF VARIANCE (ANOVA) TECHNIQUE

Step 1:

Assign all work center observations (training/frequency/ productivity combinations) to a "cell" in an ANOVA matrix. Training and frequency are the independent variables. This examination attempts to explain the statistical weight of their impact on the dependent variable (productivity).

TRAINING \ FREQUENCY	LOW	MEDIUM	HIGH	ROW (TRAINING) TOTAL
LOW				
MEDIUM				
HIGH				
COLUMN (FREQUENCY) TOTAL				OVERALL TOTAL

Step 2:

Once all work center observations are classified in the appropriate cell in an ANOVA matrix, a "cell average" productivity figure is computed in the following manner:

$$\text{CELL AVERAGE} = \frac{\text{All Productivity Numbers for Work Centers in the Cell}}{\text{Number of Work Centers in the Cell}}$$

This average provides a measure of the impact of a specific level of frequency across different training levels.

A "row/column total" productivity fig[illegible] is computed for each row/column in the ANOVA matrix. These totals are simply defined:

ROW/COLUMN TOTAL = ΣAll Cell Average Productivity Figures in Each Row/Column.

Step 3:

Once all averages and totals have been computed, variation figures must be computed for the analysis. The following variation figures (provided with their mathematical definitions) are computed:

$$V\text{, Total Variation} = \Sigma(\text{Cell Average Productivity Figures})^2 - \frac{(\text{Overall Total})^2}{(\text{Number of Rows})\ (\text{Number of Columns})}$$

$$V_T\text{, Training Variation} = \frac{\Sigma(\text{Row Total Productivity Figures})^2}{(\text{Number of Columns})} - \frac{(\text{Overall Total})^2}{(\text{Number of Rows})\ (\text{Number of Columns})}$$

$$V_F\text{, Frequency Variation} = \frac{\Sigma(\text{Column Total Productivity Figures})^2}{(\text{Numbers of Rows})} - \frac{(\text{Overall Total})^2}{(\text{Number of Rows})\ (\text{Number of Columns})}$$

$$V_E\text{, Error Variation} = V\ (\text{Total Variation}) - V_T\ (\text{Training Variation}) - V_F\ (\text{Frequency Variation})$$

These statistics describe the variation of the observed work center productivity figures around an overall mean productivity value. The formats are standard statistical variation formats, and so no explanation of their structure will be offered here.

In our analysis of the impact of training and frequency on productivity, these variation figures are crucial. If it can be shown that the variation attributed to frequency/training is larger than the error variation by a certain amount, then we can conclude that those factors do have a positive impact on productivity.

Step 4:

Calculate "mean square" values for the specific variations computed in Step 3. This is a simple procedure where V_T, V_F, and V_E are divided by their associated "degrees of freedom" to come up with a mean square value:

$$MS_T \text{ (Mean Square Training)} = \frac{V_T}{D.F._T \text{ (Degrees of Freedom for Training Variable)}}$$

$$MS_F \text{ (mean Square Frequency)} = \frac{V_F}{D.F._F \text{ (Degrees of Freedom for Frequency Variable)}}$$

$$MS_E \text{ (Mean Square Error)} = \frac{V_E}{D.F._E \text{ (Degrees of Freedom for Error Variable)}}$$

Step 5:

Use the "mean square" values calculated in Step 4 to calculate an "F-Statistic" for both training and frequency. The F-Statistic is a statistic that serves to measure the explanatory power of an independent variable on a dependent variable. The statistic is computed in the following form:

$$\text{F-Statistic} = \frac{\text{Mean Square Variance Attributed to a Specific Independent Variable}}{\text{Mean Square Error Variance}}$$

A large F-Statistic intuitively says that the independent variable tested has a much larger impact on the dependent variable than simple random change, or, in a statistical sense, the independent variable is "significant."

Step 6:

Once the F-Statistics for training and productivity have been computed, the actual determination of the significance of those two variables on productivity can be made. In order to perform this determination of significance, two different hypotheses have to be advanced:

H_0: Row (Column) $Average_1$ = Row (Column) $Average_2$ = Row (Column) $Average_3$

(In words, this hypothesis states that training/frequency differences do not lead to statistical differences in productivity).

and

H_1: Row (Column) $Average_1$ ≠ Row (Column) $Average_2$ ≠ Row (Column) $Average_3$

(Training/frequency differences do lead to statistical differences in productivity).

To make a determination as to which hypothesis should be accepted, the F-Statistic for both training and frequency computed in Step 5 should be compared against a value of the F-Statistic at a specific level of confidence. If the F-Statistic (computed) > F-distribution (at a specific level of confidence), then H_0 is rejected and H_1 is accepted. In effect, this conclusion says that the independent variable being tested (training or frequency) does have a statistically measurable impact on productivity at a specific level of confidence.

APPENDIX C

ABBREVIATIONS

ABBREVIATIONS

AFB	Air Force Base
AFR	Air Force Regulation
AFLCR	Air Force Logistics Command Regulation
AFSC	Air Force Specialty Code
AGS	Aircraft Generation Squadron
AMU	Aircraft Maintenace Unit
ANOVA	Analysis of Variance
CDC	Consolidated Data System
CRS	Component Repair Squadron
CONUS	Continental United States
DCM	Deputy Commander for Maintenance
DoD	Department of Defense
EMS	Equipment Maintenance Squadron
FTD	Field Training Detachment
MDC	Maintenance Data Collection
MMICS	Maintenance Management Information and Control System
MTS	Mobile Training Set
MI&L	Manpower, Installations and Logistics
MRA&L	Manpower, Reserve Affairs and Logistics
OASD	Office of the Assistant Secretary of Defense
OSD	Office of the Secretary of Defense
OJT	On-the-Job Training
RTOK	Retest-Okay
SAMT	Simulated Aircraft Maintenance Trainer
SRD	Standard Reporting Designator
TAC	Tactical Air Command
TFW	Tactical Fighter Wing
TTW	Tactical Training Wing
WUC	Work Unit Code

END

FILMED

7-85

DTIC